U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 76.

L. O. HOWARD, Entomologist and Chief of Bureau.

FUMIGATION FOR THE CITRUS WHITE FLY,

AS ADAPTED TO FLORIDA CONDITIONS.

BY

A. W. MORRILL, Ph. D.

Special Field Agent.

Issued October 31, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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White Fly Investigations.

C. L. Marlatt, *in charge.*

A. W. Morrill, E. A. Back, W. W. Yothers, *special field agents.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., June 11, 1908.

Sir: I transmit herewith, for publication as Bulletin No. 76 of this Bureau, a report on fumigation for the white fly, as adapted to Florida conditions, by Dr. A. W. Morrill, special field agent.

The investigation of the white fly problem in Florida is now in its second year, and the results gained of immediate practical importance are those which indicate best methods of control. Fumigation with hydrocyanic-acid gas during the short dormant period in winter, when there are no winged insects, seems to afford the greatest measure of control or possible extermination. Gas fumigation under the horticultural conditions obtaining in Florida orange groves and the peculiarities of climate presents rather a distinct problem. This bulletin gives the results of the fumigation experiments of two winters in Florida, and demonstrates the entire applicability of this method of control to the white fly. This investigation has been under the general direction of Mr. C. L. Marlatt, Assistant Chief of this Bureau, with Doctor Morrill in field charge. The latter was aided during the winter of 1906–7 by Mr. Stephen Strong, formerly horticultural commissioner of Los Angeles, Cal., and an experienced fumigator, and Mr. A. C. Morgan, and during the winter of 1907–8 by Messrs. E. A. Back, W. W. Yothers, and R. S. Woglum.

The white fly is the big insect problem of Florida and other citrus districts on the Gulf coast, and the information given in this bulletin will be of immediate practical value to all citrus growers of the region indicated.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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INTRODUCTION.

The discovery of the value of hydrocyanic-acid gas as an insecticide against citrus pests is properly considered one of the most important advances in economic entomology.* This gas was first used by Mr. D. W. Coquillett, who in 1886 was detailed by Dr. C. V. Riley, the Entomologist of the U. S. Department of Agriculture, to experiment with insecticides against the cottony cushion scale (*Icerya purchasi* Mask.) in California. The process was afterwards brought to its present degree of usefulness through the extensive experiments of Mr. Coquillett, and is now generally recognized in the citrus-growing sections of California as the most practicable and efficient method of controlling the black, red, and purple scales. It is now used in combating citrus scales in South Africa, New South Wales, and elsewhere, with results so satisfactory that wherever it has once been tested it has proved its superiority over all other methods.

In the eastern part of the United States Prof. H. A. Morgan conducted experiments with hydrocyanic-acid gas against citrus scales in southern Louisiana during the winter of 1892–93. Messrs. W. T. Swingle and H. J. Webber, of the Department of Agriculture, were the first to use this treatment against the white fly in Florida, conducting their experiments in February, 1894. In the winter of 1900–1901, Prof. H. A. Gossard, then entomologist at the Agricultural Experiment Station of Florida, aided during a portion of his experiments by Prof. C. W. Woodworth, of the Agricultural Experiment Station of the University of California, undertook some experimental fumigation work against the white fly. The results were sufficiently satisfactory to lead Professor Gossard to the conclusion that the efficiency of this treatment against the white fly is such that if a fumigated grove were segregated from all others, one fumigation would render it so nearly clean that it would need no additional treatment for two or three years. It was predicted that a process that has been found so valuable in other parts of the world is certain eventually to come into favor in Florida.

During the last few years certain nurserymen in Florida have made use of fumigation against the white fly with good success, treating, for the most part, small-sized trees. Other parties have tested fumigation on trees of all sizes, but, for lack of adequate equipment or of a knowledge of the most economical methods of procedure and dosage requirements, have not continued.

In January and February, 1907, the writer, aided by Mr. Stephen Strong, formerly horticultural commissioner of Los Angeles County, Cal., specially appointed in this Bureau as fumigation expert, and Mr. A. C. Morgan, special field agent, temporarily transferred from the cotton boll weevil investigations, conducted careful experiments in Orange County, Fla., in order that fumigation for the white fly might be placed upon a practical basis. Modern California methods as adapted to all sizes of trees were employed and the principal results are embodied in the present bulletin.

In December, 1907, and January, February, and March, 1908, fumigation experiments were continued by the Bureau of Entomology on a larger scale, testing the conclusions drawn from the work of the previous winter and extending the investigation to cover the ground more thoroughly. In this work the writer was assisted throughout the season by Messrs. W. W. Yothers and E. A. Back, and during the month of January Mr. R. S. Woglum was also engaged in the work. Altogether nearly 4,000 trees have been fumigated in Florida in this experimental work, under the immediate supervision of the agents of the Bureau of Entomology. It is too early to include in this bulletin more than the general results of the past winter's experimental work, but the text has been made to conform to these results as far as worked out.

There remain many details concerning the fumigation process which have demanded investigation, and at the present writing these are receiving attention by agents of this Bureau who are conducting an exhaustive study of the matter in California. The present bulletin aims to give the results of experiments in fumigation for the white fly and such information and recommendations as are of immediate value to those who may contemplate the adoption of fumigation as a practice, or who may desire first to secure a small equipment in order to become familiar with the methods of procedure. The directions given herein are believed to be sufficiently detailed to enable any orange grower to conduct fumigation, after a few preliminary tests, without the assistance of experienced hands. The recently discovered occurrence of the white fly in California increases the importance of definite information concerning the requirements as to dosage.

A new system for the estimation of dosage is recommended herein, as it is believed that the usual method of judging concerning the dosage requirements for scale-insects can not give the uniformity of results which should be obtained in using this remedy against the white fly.

CONDITIONS FAVORING OR NECESSARY TO GOOD RESULTS.

ISOLATION OF GROVE.

Isolation in an infested grove is the most favorable condition for the successful control of the white fly by fumigation. A distance of one-half mile between a given grove and the nearest infested grove is sufficient to insure against appreciable interference with the results of the treatment through the migration of adults between the groves. In many if not in most cases 300 or 400 yards is sufficient isolation to prevent the treatment being made unprofitable through such migrations. It is a common experience in newly infested groves that the section which first becomes infested may be very noticeably blackened by sooty mold for two or three years before the white fly multiplies to an injurious extent in near-by sections of the same grove or in immediately adjoining groves. The experience mentioned above indicates that in isolated groves the extermination, or nearly complete extermination, which can be obtained by carefully conducted fumigation, will result in a condition of practical immunity over a period of two or more years.

CONCERTED ACTION.

Ranking next to isolation as a factor favoring success in fumigation for the white fly, is concerted action among the owners of groves in naturally isolated groups, or among all the citrus growers in the various counties. In California the organization and support of county horticultural commissions has solved the problems connected with the attainment of the concerted action necessary for the control of various citrus pests in that State. It is predicted that the white fly can never become a serious pest where such systematic campaigns against citrus insects have been organized. In Florida, Orange County has already made a beginning toward the adoption of such measures against the white fly, having organized a horticultural commission with powers equivalent to those of similar commissions in California.[a] The officials having the matter in charge, however, have not felt justified in attempting active field work on a large scale until careful experiments shall have determined what course can be followed with a certainty of uniform results.

ABSENCE OR ELIMINATION OF FOOD PLANTS OTHER THAN CITRUS.

The presence of food plants of the white fly other than citrus trees, in citrus fruit growing sections, constitutes a serious menace and in itself often prevents successful results from remedial work. For-

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[a] For the California law see Bul. 61, Bur. Ent., U. S. Dept. Agric. (1906), pp. 13–21.

tunately the list of food plants[a] is limited, and the greater number of those thus far recorded is subject to infestation only when located near or in the midst of heavily infested citrus groves. The food plants which are of most importance in connection with the white fly control are the chinaberry trees, privets, and cape jessamine, and these—except for the last, in certain sections where grown for commercial purposes—can be eradicated readily, or their infestation may be prevented where community interests precede those of the individual in controlling public sentiment. These food plants favor the rapid dissemination of the white fly from centers of infestation and their successful establishment in uninfested localities. They seriously interfere with the success of fumigation, as well as of all other remedial measures, by furnishing a favored breeding place where the white fly can regain its usual abundance in a much shorter time than would be the case if it were entirely dependent upon citrus fruit trees for its food supply. The plants mentioned, together with *Citrus trifoliata* (except where used in nurseries), and all abandoned and useless citrus trees should be condemned as public nuisances and destroyed in all communities where citrus fruit growing is an important industry. Where the destruction of chinaberry trees is impracticable for any reason, they may be rendered innocuous by taking steps to prevent their becoming heavily infested each year. This may be accomplished by either defoliating each winter or by destroying entirely all privets and cape jessamines and by thoroughly fumigating each winter all citrus trees within a distance of 200 or 300 yards of each chinaberry tree.

SEASON OF THE YEAR.

Fumigation for the white fly should be done during December, January, and February, beginning not earlier than sixteen to twenty days after the adults have disappeared, in order that all of the eggs

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[a] The complete list of food plants so far as known is as follows: Citrus (all varieties), chinaberry (*Melia azedarach* and *Melia azedarach umbraculiformis*), cape jessamine (*Gardenia jasminoides*), wild persimmon (*Diospyros virginiana*), Japan persimmon (*D. kaki*), privets (*Ligustrum* spp.), *Viburnum nudum*, *Ficus altissima*, prickly ash (*Xanthoxylum clava-herculis*), cultivated pear (*Pyrus* sp.), cherry laurel (*Prunus laurocerasus*), *Prunus caroliniana*, lilac (*Syringa* sp.). Water oak (*Quercus nigra*) has been reported as a food plant of the citrus white fly, but there is no definite record of the insect reaching maturity on this plant, and the observations made in connection with the present white fly investigations show that for practical purposes oaks may be ignored as food plants of this species. Professor Gossard reports having observed larvæ of the citrus white fly on scrub palmetto (*Sabal megacarpa*). The author once observed larvæ on the banana shrub (*Magnolia fuscatum*) but apparently none reached maturity on this plant. Dr. E. A. Back has observed two live larvæ of the citrus white fly on oleander (*Nerium oleander*). These plants (oaks, scrub palmetto, banana shrub, and oleander) may be ignored absolutely as food plants unless it is proved beyond doubt that it is possible for the citrus white fly to reach maturity on them. The cultivated fig (Ficus), and the sweet bay (*Magnolia virginiana*) have been reported as food plants, but with little doubt these reports are erroneous.

deposited by these adults may have time to hatch. It is impracticable to attempt to destroy the egg stage by fumigation, or as a rule by any other direct means. The scale-like stages, however, technically known as the larval and pupal stages, are readily destroyed when the dosage is properly estimated. In Florida the month of January is, everything considered, the most favorable month for fumigating for the white fly. Ordinarily it would probably be undesirable to continue fumigation after the adults begin to emerge in considerable numbers in the spring. This time of emergence, of course, varies according to the locality and to weather conditions, but in general is between the middle of February and the first of March. It remains for further experiments to show how far fumigation may be practiced with profit at other seasons of the year. It is certain, however, that in cases of emergency, such as the checking of the spread of the fly in newly infested groves, fumigation can frequently be used to great advantage even in midsummer.

METEOROLOGICAL ELEMENTS.

Light.—Fumigation is conducted in the absence of bright sunlight, to avoid injury to the foliage which may occur when this precaution is not observed. With tents treated with oil to make them nearly gas-tight, damage is almost certain to result from daylight fumigation. With untreated tents, however, the writer has on several occasions conducted fumigation experiments with the sun fifteen minutes high without appreciable injury to the foliage. One orange tree was fumigated forty minutes, beginning at 3 p. m., with the sun shining, without any shedding or burning of foliage resulting from the treatment. The tent was placed over the tree twenty-five minutes before generating the gas, and at the beginning of the forty-minute period the temperature was 79.5° F., or 4.5° higher than the outside temperature. Twenty and one-half ounces of potassium cyanid were used, and 97.7 per cent of the white fly pupæ were destroyed. This amount of cyanid was 4½ ounces less than the amount called for by the table given in the Appendix. At the time of fumigation, the foliage on the tree was very much curled by drought and after a few rains became normal in appearance without the shedding of a single leaf. The leaves, at the time of the treatment, when torn seemed to be as dry as paper, although many pupæ of the white fly on neighboring trees in a similar condition produced adults, as did the nine specimens which were known to survive on the fumigated tree. It is probable that future experience will show that trees whose foliage is curled as a result of drought are not nearly so liable to injury by daylight fumigation as are trees whose foliage is in perfect condition.

Fumigation can safely begin with sundown, or, during the fumigating season in Florida, between 4 and 5 o'clock p. m. On dark, cloudy days fumigation seems entirely safe at any time with untreated tents.

Wind.—The effect of wind upon the results is so marked that fumigation should not be attempted with anything stronger than a slight breeze, particularly if the tents have not been rendered gas-tight or nearly so by the use of a "filler." It has been found, with an untreated tent, that with a dosage sufficient to destroy 100 per cent of white fly pupæ, a brisk breeze renders the results so uncertain that the effectiveness may be as low as 30 per cent in some sections of the tree, while in others the destruction of the insect may be complete.

Atmospheric humidity and dews.—The presence of moisture in the form of dew does not seem to have any deleterious effect upon the foliage, although in California it is generally considered necessary to materially increase the dosage in such cases to insure the effectiveness of the work against scale insects. Prof. H. A. Gossard[a] concluded that "moisture did not seem to interfere with the efficiency of the work, unless the leaves were almost dripping, when it became a factor of much disturbance, though not as great as we had thought probable."

The experiments conducted by the writer and assistants during January and February, 1907, show that moisture on the foliage during the period of exposure has no marked effect on the foliage or upon the efficiency of the gas against the white fly. In the six instances where the leaves were wet with dew, examination showed that 100 per cent of the insects were destroyed in all cases but one, and in this only a single specimen out of 102 under observation, before and after fumigation, survived the treatment.

The results of the tests concerning the effect of atmospheric moisture on the efficiency of the fumigation treatment are given in Table I.

TABLE I.—*Effect of atmospheric moisture on efficiency of fumigation.*

Experiment No. [b]	Air humidity.	Condition of tent.	Condition of leaves.	Per cent of insects killed.	Amount of cyanid used.	Amount of cyanid recommended in tables; 45 minutes exposure.
	Per cent.				*Ounces.*	*Ounces.*
30.7	100	Wet......	Wet......	100	30	24
40.2	94+	....	Moist.....	100	32	27
45.12	100	Wet......	Wet......	100	$15\frac{3}{4}$	14
45.21	87	Damp....	....	89.3	9	11
45.22	87	Damp....	....	99.8	$13\frac{3}{4}$	18
45.25	96	Damp....	Moist.....	100	$33\frac{1}{2}$	32
45.27	100	Wet......	Wet......	99.7	$36\frac{1}{2}$	34
50.2	97	....	Moist.....	100	28	19
60.2	64	Damp....	Dry.......	100	22	$26\frac{1}{2}$
60.19	90	Damp....	Dry.......	100	$27\frac{1}{2}$	$26\frac{1}{3}$

[a] Bul. 67, Fla. Agr. Exp. Sta., pp. 647–648.

[b] The number preceding the decimal point indicates the length of exposure.

On several occasions it was observed that the tent felt somewhat damp when being handled, although the humidity recorded by a standard sling psychrometer had not reached complete saturation. On other occasions, as shown by the above data, the foliage was covered with a dew like a fine mist when the sling psychrometer indicated as much as 6 per cent below complete saturation. For practical purposes, however, the moisture on the leaves may be considered as indicating a condition of 100 per cent atmospheric moisture. Blank spaces in the table indicate that no note was made concerning this particular point, although the tent was evidently "wet" in experiments 40.2 and 50.2 and the leaves were evidently "dry" in experiments 45.21 and 45.22. In the experiments summarized in Table I the possibility of reducing the efficiency of the gas through absorption by the moisture on the leaves and tent had to be taken into consideration. To eliminate this feature and to determine the effect of the gas on larvæ and pupæ of the white fly when leaves are wet artificially, tests were made by wetting the leaves both by dipping and by means of an atomizer. The results are summarized in Table II.

TABLE II.—*Effect of artificially wetting leaves on efficiency of fumigation.*

Experiment No.	Air humidity.	Amount of cyanid used.	Amount of cyanid recommended in table.	Total number of insects under observation.	Per cent of insects killed.	Number of insects on leaves wet artificially.	Per cent of insects killed on leaves wet artificially.	Method of wetting.
	Per cent.	*Ounces.*	*Ounces.*					
30.6	44	20	29	242	71	21	95.2	Dipped.
40.6	47	17½	21	392	88	149	90.6	Sprayed.
40.7	55	8½	13	132	80	40	87.5	Dipped.
40.8	61	17¼	29½	223	96	93	98.9	Sprayed.
40.9	54	12	27	342	93	20	95	Sprayed.
40.13	63	24	28	736	100	567	100	Dipped.

In the above experiments—omitting the last one, in which all insects were killed—1,331 insects were under observation. Of these, 323 were on leaves wetted artificially. The weighted average of the insects killed on these leaves is 92.5 per cent. Of the 1,008 insects on the dry leaves 852, or 84 per cent, were killed. This seems to be of considerable significance in view of the fact that in every instance where less than 100 per cent of the insects were killed, the percentage of killed was greater on the artificially wetted leaves than on the dry leaves.

Taken as a whole the results summarized in the two foregoing tables show conclusively that moisture on the leaves in the form of dew does not reduce the efficacy of the gas in destroying the insects, but possibly increases it. In the experiments in which moisture was a factor no injury to the foliage followed, even when the dosage was increased fully one-half above the amount called for by the table in the appendix of this bulletin. The results give no justification to

the practice of some fumigators who, as has been stated, increase the dosage when the tents and foliage are wet with dew. It seems that the difficulty in handling wet tents is the only consideration for which it is necessary to cease work on foggy nights, everything else being favorable.

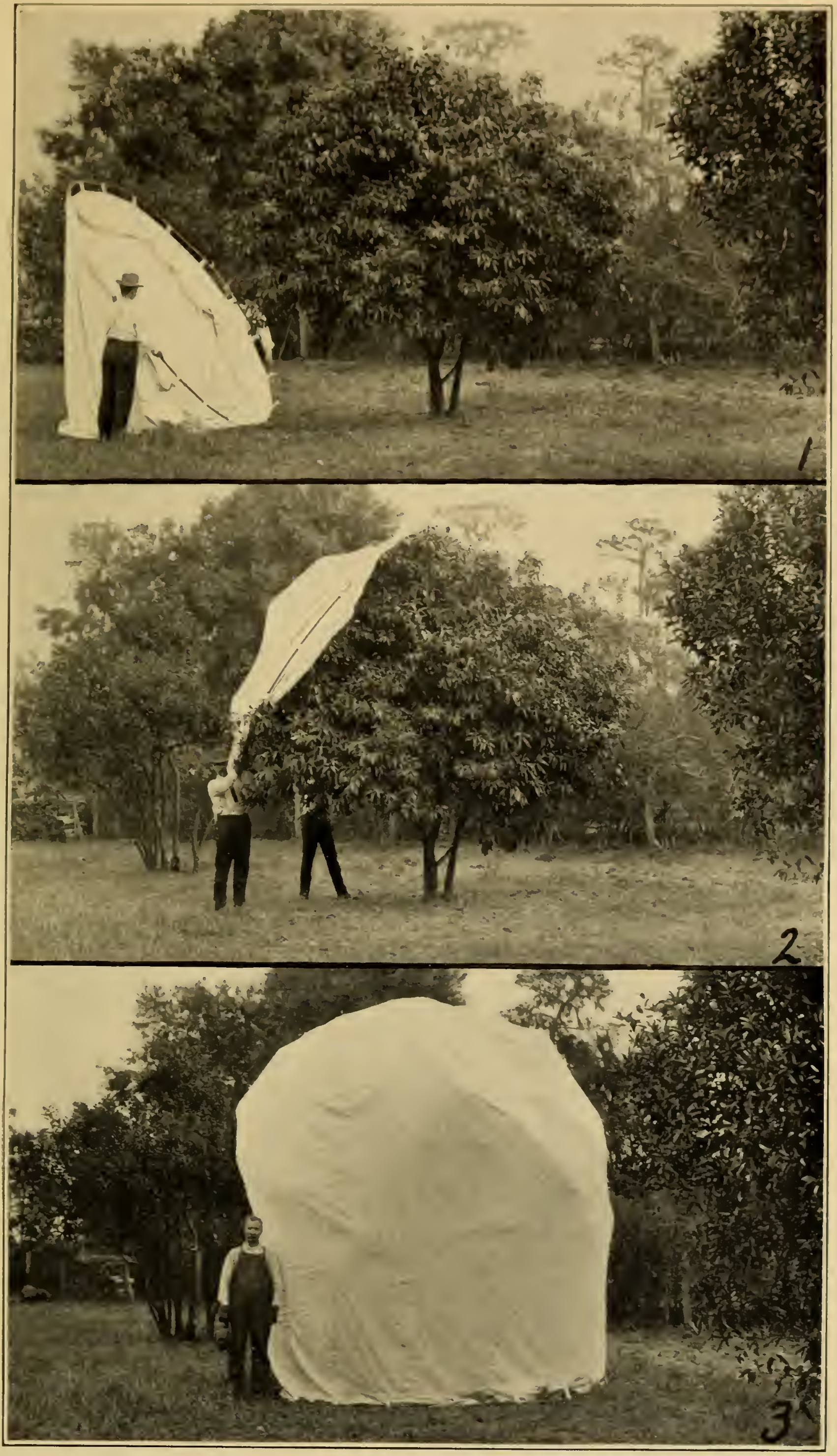
SIZE OF TREES AND REGULARITY OF SETTING.

While it is true that it is possible to place a fumigating tent over any citrus tree regardless of size, the author strongly recommends that orange growers make a practice of pruning large seedling trees so that they will not exceed 28 or 30 feet in extreme height. Such pruning will greatly reduce the cost of labor in fumigating and will be of considerable advantage from the standpoint of picking the fruit. It is probable that the now generally recognized all-around advantage of low-pruned fruit trees applies equally well to citrus as to other kinds of fruits. Another consideration of importance is the regularity in the setting of orange groves and the proper spacing of trees. In Florida various factors have resulted in many groves being too crowded or too irregularly set to permit of the easy handling of fumigating tents. While it is well to bear these things in mind to the end that all Florida groves may gradually be adapted to reduce the labor and expense of fumigation, yet even under present conditions it is exceedingly rare that fumigation is rendered absolutely impracticable by the size of trees or the irregularity of their setting.

EQUIPMENT.

TENTS.

Styles of fumigating tents.—Two styles of tents are now in use for orchard fumigation, the bell or hoop tent (Pl. I.) and the sheet tent. The first is bell-shaped and held open at the mouth by a hoop of $\frac{3}{4}$-inch gas pipe. Tents of this style are preferable for use only when the trees in a grove are uniformly less than 12 feet in extreme height. Sheet tents are made in the form of flat octagons and, being adaptable for trees of all sizes, are in California used almost exclusively. Plate I, figure 3, shows a tree which is 14 feet in extreme height and 14 feet in extreme expanse, covered by a hoop or bell tent. When the tent is in position covering the tree the measurements are: Height, 13 feet, and diameter, 12 feet. Hoop tents are not always easily placed in position over trees of this size, and it is believed that ordinarily a sheet tent is more desirable for trees of all sizes. A third style of tent which will be found useful in fumigating small trees is the box tent in the form of a rectangular prism. This will probably prove advantageous for trees 5 feet or less in height. The light wooden framework supporting the cloth cover gives a form to the



FIGS. 1-3.—METHOD OF COVERING SMALL TREE WITH BELL OR HOOP TENT. (ORIGINAL.)

inclosed space which permits of economical use of chemicals with greater uniformity of results.

Construction of tents.—The construction of the box covers such as suggested in the foregoing paragraph is a simple matter and convenient patterns will suggest themselves at once to anyone desirous of fumigating small trees. The framework should be light but well braced, and for a covering either 6½-ounce drill, painted to render it as nearly gas-tight as possible, or oilcloth is recommended.

Prof. C. W. Woodworth, of the California experiment station, gives the following directions for cutting the cloth for bell tents:[a]

All of these tents are made in the same manner, and are the most economical in cloth of any tents made. Commonly the tent is made by the "cut and fit" method. These tents may be made with scarcely any loss, if cut according to the following directions: Measure off strips of a length equal to twice the height plus one-tenth the diameter of the tent desired. These will make two strips each by marking the exact middle and measuring off on one edge from the middle line one-quarter of the diameter of the tent and on the other one-half the diameter. Now, take a long strip of molding and bend it so as to touch these three points and mark off the curve so produced. This allows for the seam. In making up, sew the two cut edges together in each pair of strips.

As has been stated, sheet tents, or more properly covers, are flat, regular octagons. The dimensions are sometimes stated in terms of the true diameter (i. e., the distance between opposite corners), but for practical purposes the distance between parallel sides should represent the size of the tent, for the reason that this represents within about 2 feet (which must be allowed to rest on the ground) the distance over the tallest tree that a given sheet can cover measuring from the ground on one side to the ground on the other, over the center of the tree.

Hereafter in this bulletin the size of octagon covers as stated should be understood to refer to the distance between parallel sides. The specifications should be carefully worked out before beginning the construction of a sheet tent as well as of other styles. First, the dimensions of the tallest tree which the tent is required to cover should be estimated. This may be accomplished by throwing a tape attached to a reel over the top of the tree and measuring from ground to ground. When covered, the weight of the tent will reduce the extreme height of the tree in most cases by from 2 to 4 feet, according to the weight of the tent and form of the tree. It will be well to allow at least 4 feet of the tent to rest on the ground when covering the largest tree. The desired size having been determined, a diagram of an octagon should be constructed on paper, as indicated in figure 1. Each side of the octagon when constructed will be equal approximately to two-fifths of the distance between the parallel

[a] Circular No. 11, Cal. Agr. Exp. Sta., pp. 9–10.

sides of the octagon. The number of square yards of cloth required is about 18 per cent, or between one-sixth and one-fifth less than for a square the sides of which are equal to the distance between parallel sides of the octagon.

In California 8-ounce army duck has been used almost exclusively for making sheet covers, while in Cape Colony, South Africa, a No. 10 duck ranking in weight between 12-ounce and 15-ounce is commonly used. The heavier weights are not only more durable but presumably confine the gas better. A good grade of 6½-ounce drill, however, as shown later by the results obtained with a bell tent of this material, seems to be fully equal to the 8-ounce duck commonly used in California. Until careful experiments shall have determined the relative tightness of various weights of duck it is recommended that sheet tents be constructed throughout of 8-ounce duck or of 8-ounce duck in combination with a "skirt" of 6½-ounce drill. The author has seen a sample of 8-ounce drill which is no more expensive than the best brands of duck of this weight, but is evidently far superior as regards tightness. Anyone contemplating the ordering of a fumigating outfit should procure as many samples as possible of different brands of suitable cloth and select the closest woven brand.

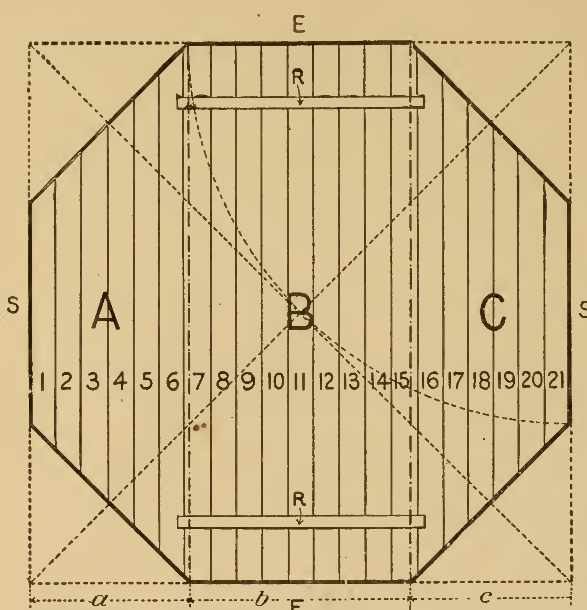


FIG. 1.—Plan for construction of octagonal sheet tent 50 feet across, showing lines used in constructing octagon: *A*, *C*, side sections; *B*, central section of full-length strips; *E*, *E*, so-called "ends" of tent; *S*, *S*, so-called "sides" of tent; *R*, *R*, reinforcements; 1–21, strips of duck 29½ inches wide, overlapped ½ an inch at the seams. (Original.)

The strips when cut should be overlapped three-eighths or one-half inch and double stitched and all raw edges should be hemmed. In calculating the number and length of strips the overlapping will reduce the width of the cloth from three-fourths inch to 1 inch. As an illustration of the method of calculating the length of the strips used in making an octagonal tent of 8-ounce duck, 50 feet may be taken as the desired size. This is equal to 600 inches and the width of the cloth, if 29.5 inches, will be reduced to 28.5 if overlapped one-half inch at the seams. By dividing 28.5 inches into 600 inches the

nearest multiple is found to be 598.5 inches, or 49 feet and 10½ inches, which is sufficiently close to the desired width for practical purposes. The number of strips in a tent 598.5 inches wide is 21. The middle section B (fig. 1) is approximately two-fifths the entire width, or 239.5 inches. Deducting this from 598.5 inches, the entire width, the remainder, 359, equals the sum of the widths of sections A and C. These sections being equal, the width of each is 179.5 inches. The number of strips in each section can now be readily calculated. The 21 strips should be numbered on the diagram from left to right. Section A requires six strips and 8.5 inches of the seventh. Similarly, section C requires six strips, beginning at the right (twenty-first to sixteenth, inclusive), and 8.5 inches of the fifteenth. Section B requires the remaining 20 inches of strip No. 7, 20 inches of strip No. 15, and seven entire widths, thus making the total of 21 strips required.

The cutting of the cloth can be done without waste if the details of construction are well planned. In the above tent seven strips 50 feet long (49 feet 10½ inches) should first be cut for section B. Strips Nos. 7 and 15 are next cut and the outside corners cut at an angle of 45 degrees, as indicated in the diagram. Each strip for sections A and C is cut shorter by its own width outside at each end than the strip preceding it. Thus the required lengths of the side strips are found by matching the inner edge of the new one to the outer edge of the one before it. It is desirable to have the central section, B, made up entirely of full-length strips so that the stress will not be across seams. The stress is so slight, comparatively, in the side sections A and C, that this is not an important point.

Shrinkage of the goods after being thoroughly wet is an important consideration in the economical construction of fumigating tents. In order that the tents approximate a regular octagon, after having been used for fumigating purposes, it is necessary either to have the goods thoroughly shrunk before cutting or to make allowance for subsequent shrinkage by cutting the strips longer. A test made with a brand of 8-ounce duck commonly used in California for fumigating tents showed that the shrinkage lengthwise of the goods amounted to 7.5 per cent, and, crosswise 0.9 per cent; this means that in a 50-foot tent the shrinkage would result in the full-length strips shortening 3¾ feet, while the tent would shrink less than 6 inches crosswise of the strips. Such irregularities might be remedied by a skirt of 6½-ounce drill, but it is simpler to plan to have each strip cut longer by a given amount for each 1 per cent of difference in the lengthwise and crosswise shrinkage. In the case referred to above this difference is 6.6 per cent, and each per cent represents an actual difference of 6 inches. A 50-foot tent constructed in this manner

would therefore measure before shrinkage 52¼ feet (49 feet 10½ inches + 3 feet 4 inches) lengthwise of the strips through the middle section, and 49 feet 10½ inches crosswise of the strips. After shrinking, the dimensions would be approximately 49 feet 4½ inches in each direction. The two sides of the octagon which are formed by the ends of the full-length strips are known as the "ends" of the tent and the sides of the octagon which are parallel with these strips as the "sides" of the tent.

By gathering the cloth around a tightly-rolled wad of burlap and tying on an iron ring, a convenient arrangement is made for attaching the hooks or poles when covering trees. (See fig. 2.) In the case of the smaller sizes of sheet tents, which are to be handled with simple poles, these rings are unnecessary, attachments being made in the manner hereafter described. For large tents, measuring more than 42 or 45 feet, it is probably best to use the rings in all cases. It is most convenient to have one of these rings located a few feet in from each of the four corners of the middle section of full-length strips (fig. 1, *B*). In general, the distance in from the margin should be from one-twelfth to one-tenth of the distance between parallel sides of the tent, and the distance between the two rings on each side should be from one-third to two-fifths of the distance between parallel sides. To the ring mentioned a chain link is sometimes attached (*e*), called a "jingler," the object being to indicate the position of the ring when the operator shakes the tent, enabling him readily to locate it at night.

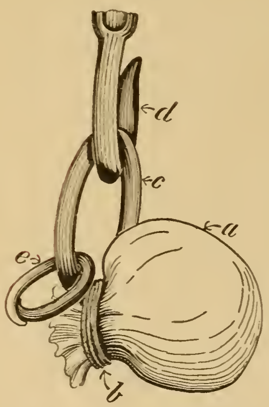


FIG. 2.—Method of attaching hooks to tent when covering trees with aid of derricks: *a*, Tent gathered around ball of burlap or other suitable object; *b*, stout cord for attaching ring; *c*, catch-ring; *d*, hook on pulley block; *e*, lap link or "jingler." (Original.)

In order to provide for the increased stress on the cloth at the points where these rings are to be located, a reenforcement should be stitched on near each of the "ends" of the tent. The main stress in handling a tent is directly behind the catch rings or places of attachment when poles are used without rings. There is also considerable stress across the tent directly between the two rings or places of attachment. Both of these stresses may be provided for by a reenforcement consisting of one-half width of the goods used in constructing the tent, sewed entirely across the full-length strips of the middle section and extending 2 or 3 feet onto each of the side sections. These reenforcements are located in accordance with the directions given in the preceding paragraph and as shown in figure 1 (*R*, *R*).

A skirt of 6½-ounce drill is of considerable advantage in reducing the weight, especially in the case of the larger sizes of tents. This drill is usually about 28 inches wide, and when a skirt is to be used allowance is made for one or two widths in constructing the diagram and in figuring for the cutting of the 8-ounce duck. Sometimes the skirt is run all around the margin, but it is preferable to have the full-length strips (section B) extended the entire length of the tent and the drill sewed to the three sides of section A and of section C. When the skirt extends all the way around, when shifting the tent by means of poles or uprights, the rings should always be located on the duck inside of the skirt, to avoid too great stress upon the lighter material.

Painting, oiling, mildew-proofing, and care of tents.—Various methods have been used to preserve and to increase the tightness of fumigating tents. Linseed oil was one of the first materials tested for increasing the tightness of the cloth,[a] but experience has shown this to be undesirable when used either by itself or in combinations, on account of the deterioration in the strength of the cloth and the liability to burn or rot when long left folded. Painting the cloth with black paint, with an inferior grade of glue, called "size," and with a mucilaginous juice of the prickly pear cactus (*Opuntia* sp.) are three methods mentioned by Mr. D. W. Coquillett in a report dated in October, 1890, as in use in California. In recent years these three methods have all been used more or less, the last the most extensively of the three. At present the most usual practice of California fumigators is to use untreated tents or tents proofed against mildew by dipping and boiling in a solution of tannin. This last treatment is not considered of any value in rendering the tent tighter except by ordinary shrinkage, which would be accomplished as well in due course after using one or two nights, particularly in Florida, where heavy dews are usual. The method of treatment with the tannin solution, as reported by a committee on fumigation appointed by the Claremont (California) Horticultural Club and published in various horticultural and agricultural papers, is as follows:

To prevent ruination by mildew when the tents are damp, they must be dipped. This is done in a large tank, made either of galvanized or boiler iron. These should be 3 by 10 feet and 2½ feet deep. The boiler should be rounded. This must be on a good arch, so as to permit a fire under it. The smoke pipe or chimney of the arch must be high, to secure a draft. A derrick made by three poles above the tank, supplied with pulleys and a rope, makes dipping easy and permits raising of the tent and dripping after dipping is completed. It also aids in keeping the tent from the bottom of the tank and burning, which must be avoided. The tank is filled to near the top with water and made very dark by adding a half barrel of oak extract or tannin. This is well stirred. The tannin should not be added until the water is boiling. The tent is lowered into the tank of boiling water and extract and boiled for half an hour. It is

[a] Report of Commissioner of Agriculture, 1887, Report on the Gas Treatment for Scale Insects, by D. W. Coquillett, p. 126.

now raised from the water and after dripping ceases it is spread out to dry. The tank is filled again and the tannin is added until the color is a reddish brown, and then another tent may be dipped.

In Florida fumigating tents become thoroughly wet nearly every night they are in use, but even when untreated will not deteriorate to any great extent during two or three months' use if thoroughly dried each day, and more especially before being finally rolled up for storage during the seasons when not in use. Tents are conveniently dried each day by simply leaving them on the last tree covered until dried by the sun. The edges of the tent should be straightened out as soon after sunrise as possible, and folds in the tent should be arranged from time to time to facilitate drying. Such work, of course, should not ordinarily be considered as part of the work of the fumigating crew, but can be readily attended to by some laborer employed at the grove. It is considered by some fumigators that when tents are treated with oil it is unsafe to leave the trees covered during bright sunlight, but untreated tents can be safely dried in this manner. Drying is probably hastened by pulling the tents partly off so as to make an open space on one side to give circulation of air. Frequently it is a good practice to pull a tent wholly or partially over two trees in order to facilitate drying. When tents are dry, to prevent wetting by rain and subsequent trouble in drying, they should be rolled up as compactly as possible and arranged to shed water as well as practicable, or they may be covered with waterproofed ducking or stored for the time being in a dry place.

Tents must be kept in repair during the fumigating season and examined frequently during the daytime for holes which need patching. If tents are always pulled lengthwise of the strips of the cloth, there is little danger of tearing, except when there is much dead wood on the trees. One of the tents used by the agents of the Bureau of Entomology during the winter of 1906–1907 was used to cover upward of 100 trees without any injury of this kind.

POLES AND UPRIGHTS.

Poles and uprights are used, as shown in the illustrations (Pls. II, III), for raising the front edge of the fumigating tents when covering a tree or pulling the tent from one tree to the next in the row. The simple poles are as a rule used for tents not exceeding 48 feet in diameter, and usually vary from 12 to 20 feet in length, according to the height of the trees to be covered. In California straight-grained Oregon pine 2 inches in diameter is generally preferred for poles not exceeding 18 feet in length; for poles longer than 18 feet the diameter should be 2½ inches. In the Gulf regions it is recommended that seasoned cypress poles be used, as these are much lighter than the available pine. Although only a single pair need be used with an

FIGS. 1-3.—METHOD OF COVERING SMALL TREE WITH SHEET TENT BY MEANS OF POLES. (ORIGINAL.)

FIGS. 1-5.—SUCCESSIVE STAGES IN THE OPERATION OF SHIFTING A SHEET TENT FROM ONE TREE TO THE NEXT IN THE ROW. FIG. 6.—FIRST TENT READY FOR INTRODUCTION OF CHEMICALS; "TENT MEN" SHIFTING THE SECOND TENT IN THE SERIES.

[The tents are considerably larger than necessary for the trees shown in the photographs.] (Original.)

outfit of as many as twenty-five or thirty tents, extra poles should always be on hand as a provision against breakage. A one-half inch rope of either manila or cotton, about one and one-half times the length of the poles, is attached about 3 or 4 inches from the top of each one that is in use. The tops of the poles are constructed in various styles for catching the rings on the tents. The end of the pole may be cut to allow the ring to slip over the end for a short distance, for instance 1½ or 2 inches, and to hold the rope in position. Two hardwood pegs driven through auger holes about 1½ inches apart at right angles to one another will serve this purpose. The most convenient form for general use is the simple rounded top over which the cloth of the tent is doubled and held in place by a half hitch of the rope (Pl. II, figs. 1, 2). The lower end of the pole should be pointed to prevent its slipping on the ground when the tent is being lifted.

For use with sheet tents which are too large for convenient handling with the poles described, a pair of uprights or derricks is needed. These are somewhat heavier poles, with braced crosspieces at the bottom to prevent them from falling sidewise when in an upright position, and each is provided with a pulley at the top (see Pl. IV, fig. 2). When not attached to the ring in the tent the swinging block is hooked to a ring bolt or stout staple located on the upright near the tops of the braces. The poles are 25 feet or more in length, from 3 to 4 inches in diameter at the base and tapering to from 2 to 3 inches in diameter at the top. They may be made of straight-grained knotless pine or seasoned cypress. Wherever the latter can be obtained it is preferable to pine on account of its lightness. As shown in Plate IV, figure 3, crosspieces about 1 by 3 inches in section are spiked or bolted to each side across the bottom, and brace pieces about 2 by 4 in section extending from between the ends of the brace pieces to the main pole are bolted in position. The crosspieces should be 6 feet in length for derricks 25 or 26 feet high and increasing to about 7½ or 8 feet in length for 32 or 33 foot derricks. In the writer's experience derricks are sufficiently long that are within 2 to 3 feet of the extreme height of the trees to be covered, as a consequence of the elasticity of the citrus branches and the fact that within this distance of the extreme top the branches are almost invariably slender. A guy rope one-half or five-eighths inch in diameter and about one and one-half times the length of the upright is attached to the top of each, just above the pulley block. It is convenient to have these ropes easily removable so that they can be used in tying the tents into compact bales when rolled up for transportation or storage. The lifting tackle consists of a rope of the same size as the guy rope and a little less than three times as long as the upright. One end of this is attached to the fixed pulley block at the top of the upright, passes through the movable block, then through the upper fixed block, and the free end is usually tied to one of the brace pieces.

MISCELLANEOUS REQUIREMENTS.

According to the method of procedure hereinafter described and recommended for use in fumigating for the white fly, when an outfit of more than four or five tents is in use, a cart or stone drag and a horse may be desirable for carrying the materials from tree to tree. An ordinary hand push-cart can be recommended as convenient for use in some cases. When a horse or a hand push-cart is not available, a box-like tray (Pl. IV, fig. 1) with handles should be constructed. This should be large enough to contain a supply of acid and cyanid for all of the trees covered at one time by the set of tents in use. One-half of the tray should be reserved for as many 3-quart pitchers as may be needed and for the graduate, and the other half should be provided with compartments for the bags of cyanid, if weighing is done by day, or an open box for the loose cyanid if the weighing is done as each tree is fumigated. A torch should be fixed over the center of the tray, and if the cyanid is weighed as used there should be a strip of board across the tray to serve as a platform for the balances. Balances are preferable to spring scales for use in weighing the cyanid. They should not be larger than necessary for weighing 40 ounces of cyanid at once. For containing the acid temporarily, stoneware churns of a capacity of 3 or 4 gallons are much used in California, and can be recommended for use in Florida. Frequently several 3-quart pitchers are more convenient than the stoneware churns. A measuring glass of 16 ounces capacity is needed for measuring the acid, and an extra measuring glass should be provided for use in case of breakage. The acid is dipped into the measuring glasses by means of a long-handled enamel-ware dipper, or poured in from a pitcher. For carrying water a couple of large pails are needed.

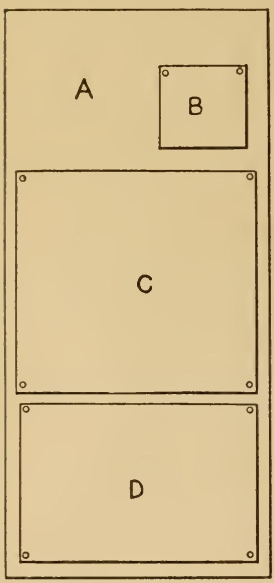


FIG. 3.—Plan for schedule board, showing convenient arrangement: *A*, space for resting lantern temporarily; *B*, scratch pad; *C*, dosage table; *D*, diagram of grove. (Original.)

The one who measures the acid and generates the gas should be provided with rubber gloves of good quality and long enough to cover the wrists well, or even the entire forearm. For generating the gas, earthernware jars from 1½ to 5 gallons capacity are necessary, according to the size of the trees and dosage required. Extra jars should be provided to obviate possible inconvenience in case of breakage. Cylindrical jars are preferable to those which narrow at the top, as the chemicals are much more likely to boil over in the latter than in the former. The cyanid, after being weighed, may be put into paper

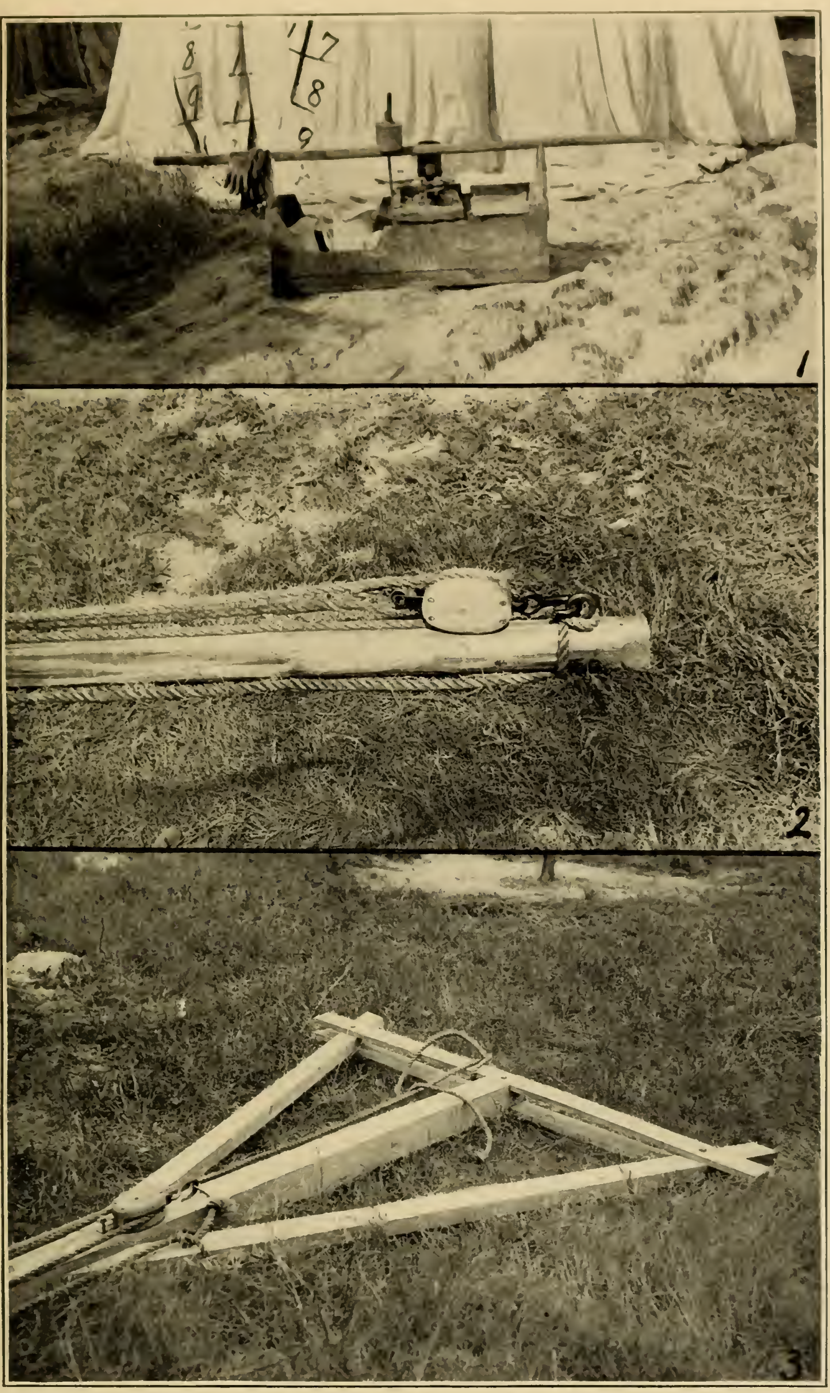


FIG. 1.—COMMISSARY TRAY: OPEN COMPARTMENT (TIN LINED) FOR CYANID AT RIGHT, BALANCES AND TORCH IN THE MIDDLE, COMPARTMENT FOR ACID PITCHERS AND GLASS GRADUATE AT LEFT. FIG. 2.—TOP OF DERRICK, SHOWING METHOD OF ATTACHING PULLEY AND GUY ROPE. FIG. 3.—BASE OF DERRICK, SHOWING METHOD OF CONSTRUCTING BRACES. (ORIGINAL.)

bags or into tin cans, or it may be emptied directly from the scoop into the generating jar. A spade or shovel should be on hand for use whenever it is necessary to weight down the edges of the tent by a few shovelfuls of earth and also for use in burying the contents of the jars. A copy of the table of dosage required for the white fly and found in the appendix of this bulletin should always be on hand. A convenient arrangement for handling the diagram of the grove and the dosage table when fumigating is illustrated by figure 3. This represents a board upon which the position for setting the lantern temporarily, and the positions for attaching diagram of the grove, dosage table, and scratch pad are indicated. For the board a side of an orange box is very satisfactory. This should be strengthened by two laths nailed across the grain on the rough side. On the

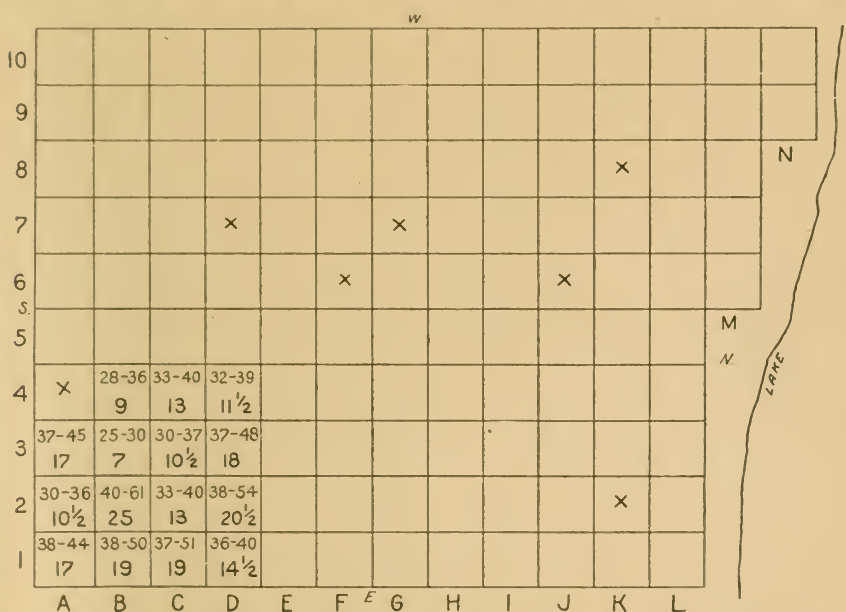


FIG. 4.—Diagram of regularly set grove in process of fumigation with an outfit of four tents: X, X, trees missing. (Original.)

smooth side at the bottom the diagram of a portion of the grove (fig. 5) should be fastened with thumb tacks. This diagram should include as much of the grove as can be fumigated in any one night and should be dated and preserved after the work for the night has been checked off on the original diagram (figs. 4, 5) of the grove as a whole. Immediately above the diagram the dosage table (fig. 3, *C*) should be located. If the board is smooth it may be painted white and the table copied thereon with pencil. If the table is on cardboard it may be fastened with thumb tacks. Above the dosage table a scratch pad (fig. 3, *B*) should be fastened in the upper right-

hand corner, while the space (fig. 3, *A*) in the upper left-hand corner is left for the fumigator to set his lantern while he is writing down on the diagram the dimensions of the tented tree and the amount of dosage. It will be found convenient to attach a pencil to this board with a short string.

The diagrams of the grove are prepared as shown in figures 4 and 5, representing a small grove set in regular and alternate rows respectively. When set with any form of regularity the individual trees may be conveniently referred to by numbering the rows in one direction and lettering them in the other. Thus the first tree of row No. 1 is called 1A, the second 1B, etc., while in the other direction the trees are referred to as 2A, 3A, etc. In measuring the circumference of the trees or in checking the correctness of the estimates based on pacing, a 75 or 100 foot tape attached to a reel is needed. Water-tight barrels are required for containing the stock of water for use during the night.

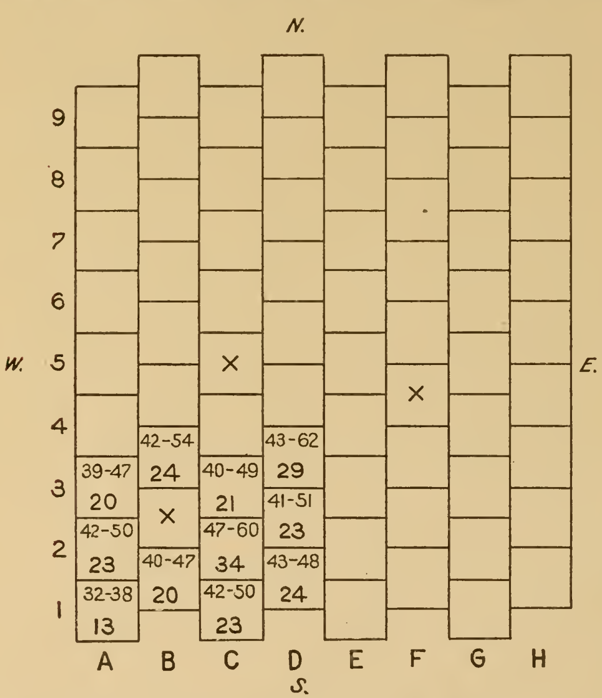


FIG. 5.—Diagram of grove with alternating trees; first four rows in process of fumigation with four tents; three sets of trees fumigated, the tents being moved from south to north: X, X, X, trees missing. (Original.)

When weighing the cyanid a tin scoop is sometimes useful, and leather gloves should be provided for the one who does the weighing. When weighing of the cyanid is to be done during the day five wooden boxes, with hinged covers, of a size that will conveniently fit into the cart, or one box with six compartments, should be constructed for use in holding paper bags of cyanid in doses of 1, 2, 5, 10, and 20 ounces, respectively. Experience will show the number and style of lanterns and torches required. A hammer, hatchet, and other incidentals can be procured as found necessary.

CHEMICALS.

DEGREE OF PURITY REQUIRED.

The materials used in generating hydrocyanic-acid gas are potassium cyanid (KCN), sulphuric acid (H_2SO_4), and water. The cyanid and acid should be purchased of a reliable dealer. The cyanid should be guaranteed to be 98 or 99 per cent, which is practically chemically pure. The acid should be guaranteed to be 66°[a] and, as additional assurance, it would be well to have a sample tested by a druggist or by the fumigator himself by using an acid hydrometer. This instrument is inexpensive and can be obtained through any druggist. A firm or hard cyanid should be obtained rather than a soft or porous product.

HANDLING, AND NECESSITY FOR PROTECTION FROM MOISTURE.

Potassium cyanid can be purchased in boxes of 200 pounds each. The cyanid readily absorbs moisture, and for this reason after a box is opened it should be kept constantly covered with burlap sacks and protected against rain when necessary. When only a few trees are to be treated and the box of cyanid is not to be completely used, within a few days at the most, it is recommended that it be stored in large-sized tin cans with covers made practically air-tight by means of cheese cloth or muslin. The acid when used in large quantities is purchased in drums containing about 1,500 pounds. In smaller quantities it is sold in carboys containing a little less than 200 pounds. The carboys make convenient receptacles for handling in the groves. In emptying from a drum into carboys a large funnel of glass or sheet lead is useful. When the carboys are boxed and not otherwise provided with handles, strips of wood may be nailed along parallel sides projecting at each end, so as to make convenient handles for two men. If carboys can not be obtained or the quantity of acid used does not require temporary containers for such amounts, large jugs may be used. In all cases the containers, except when in use, should be stoppered. For this purpose wooden plugs, made tight with asbestos, such as can be bought in sheets from hardware dealers, may be used. When the acid is to be stored in carboys for more than a few days the plugs should be made extra tight by means of plaster of Paris. For water required in the generation of the gas anything that is reasonably clean will answer the requirements.

PROPORTION OF WATER AND ACID.

The proportion of the materials theoretically required for a complete chemical reaction is 1 part of potassium cyanid, 1 part of acid, and 2 parts of water. In practice, however, an excess of acid up to one-fourth

[a] Sixty-six degrees sulphuric acid is 93 per cent strength.

more than the actual requirement is ordinarily used, while it is generally considered that the use of three or four times as much water as acid reduces the danger of shedding of the leaves from excessive dosage. The experiments conducted by the writer relating to this point have thus far given only negative results by failing to show any relation between the proportion of the water and acid and the effect of the gas upon the insects or the foliage. In 66 of the experiments summarized hereafter a record was made of the proportion of the water and acid. In nearly every case the object was to determine the minimum dosage required, and while the record included the proportions of the water and acid no effect of the variation in this regard was looked for until the results were summarized. The chances, therefore, were equal in regard to the selection of a dose of the required amount for greatest utility in the various tests. The results in connection with the proportion of water and acid used are given in the Table III:

TABLE III.—*Results obtained with varying proportions of water and acid.*

Parts of water to one part of acid.	Number experiments in which 100 per cent of white flies were killed.	Number experiments in which less than 100 per cent of white flies were killed.	Total.
2	1	2	3
2½	9	5	14
3	10	17	27
3½	0	1	1
4	11	9	20
5	0	1	1
Total	31	35	66
Less than 3	10	7	17
3 or more	21	28	49

It will be observed from the table that the results seem to favor the smaller amounts of water in proportion to the acid rather than the larger amounts. The data are not extensive enough to establish this conclusively, and it is not improbable that the difference in the percentage of white flies killed has no connection with the proportion of water and acid. It is at least evident, however, that there is no marked difference in favor of the use of water in a proportion greater than necessary for the complete chemical reaction. The Association of Horticultural Inspectors in 1903 adopted the formula usually expressed 1–2–4, meaning 1 part of cyanid, 2 of acid, and 4 of water. Mr. Wilmon Newell's laboratory experiments[a] lead him to conclude that this formula permits the volatilization of an apparently maximum amount of prussic (hydrocyanic) acid.

[a] Bul. 15, Georgia State Board of Entomology, pp. 21–24. 1905.

The element of heat due to the mixing of the acid and water is recognized as an important factor in generating the gas. According to C. P. Lounsbury[a] very nearly the maximum amount of heat is evolved when equal volumes of acid and water are used, and he advises against the use of more than 2 volumes of water to 1 of acid.

The point in question is one of those now under investigation in California by agents of this Bureau. Until conclusions are reached the writer would recommend that the chemicals be used in the proportion of 1 part of cyanid, 1 part of acid, and 3 parts of water, or 1–1–3. This formula is recommended for the present on account of results of experiments reported herein and upon which the table given in the appendix is based, being obtained with an average of 3 parts of water to 1 of acid. Future experiments may justify the California practice from the standpoint of danger to the foliage from the use of the smaller amounts of water. In the experience of the writer as reported herein, the injury to the foliage has been too slight to show any relation to the proportion of the chemicals.

PROCEDURE.

METHODS OF HANDLING TENTS.

Sheet tents.—Octagonal sheet tents, or covers, are placed in position over trees by means of the changing poles and derricks which have been described. A tree which measures in extreme height between 30 and 35 feet can be covered and made entirely ready for the generation of the gas in less than two minutes if the work is not interfered with by the too close planting of trees. Smaller trees usually require from one to two minutes, according to size. When the changing poles are used (Plate II, figs. 1, 2; Plate III, figs. 1–5) in covering small trees, one man on each side of the tree places the ring over the end of his pole if catch rings are used, or if not, makes a double fold of the cloth over the end of the pole and makes a half-hitch over it with the rope to prevent it from slipping off. With the pointed end of the pole on each side about opposite the center of the tree they then raise the end of the pole and attached tent about 8 feet, or until the pointed ends hold without slipping, and, holding on to the rope, step forward and away from the tree and pull the tent into position. Some operators prefer, after attaching the tent to the end of the pole, to stand with one foot on the pointed end and raise the pole entirely by means of the rope. Knots tied in the ropes at convenient intervals near the end are of great assistance in pulling. If the trees are so large that they require tents too large and heavy for handling by two men and yet not large enough to require the use of derricks, a third man may be employed to advantage. The edge of the tent is made fast to the

[a] Agricultural Journal (Cape Town), 1902, p. 4.

end of each pole as before, but the two operators station themselves with the rope in hand at the foot of their respective poles while the helper raises the end of each pole in turn, so that the operators can use their ropes to advantage. The committee of the Clermont Horticultural Club, of California, in their report heretofore referred to, recommended that four men, or two for each pole, be regularly employed. When trees are close planted or there is fear of breaking branches by changing the tent from one tree to the next, or there is dead wood threatening to tear the tent if simply dragged off, the practice of "skinning it off" will be found to be useful. In this method the attachments of the poles are made at the far side of the tent and the cloth slides over itself as the tent is pulled from one tree to the next.

In handling sheet tents by means of derricks (Pl. V, figs. 1, 2; Pl. VI, fig. 1) four to six men can work to best advantage. The writer has, however, with one assistant successfully handled a sheet with 26-foot derricks. After placing one of the derricks in the position for raising the tent the guy rope was fastened to a tree while the second derrick was raised. Each operator then held the guy rope by means of a loop through which the elbow was placed, giving the use of both hands while raising the tent with the tackle. Ordinarily two men should not attempt to cover a tree by themselves, particularly if there is a slight breeze. When four men are available for handling sheet tents with derricks, they proceed as follows: The sheet is pulled into position back of the tree to be covered, with the rings located one on each side. The derricks are placed one on each side of the tree, flat on the ground and their bases parallel, either directly opposite the center of the tree or within a distance of 3 or 4 feet back, whichever experience with trees of various sizes and widths of rows may show to be best. Two men station themselves, one at the base of each derrick with guy rope in hand. The other two men go to the opposite ends of their uprights and raise them to a vertical position with the assistance of the men at the bases, who pull with the guy ropes, standing on the cross pieces as long as necessary to prevent slipping. The second two men now steady the derricks while the first two walk forward and take a position for holding them in place by means of the guy ropes. The derricks are now brought to a position where the tops are 3 or 4 feet beyond the vertical in order to prevent the weight of the guy rope from causing them to fall forward prematurely. The two men at the bases of the derricks now attach the hooks of the swinging blocks to the rings of the tent and by means of the tackle raise the front edge of the tent to the tops of the derricks. These men may now tie their hoisting ropes to the braces or hold them tightly by hand while the other men pull on the guy ropes, causing the derricks to fall forward, pulling the tent over the tree. Five or six men may be needed to cover very large seedling trees such as are

FIG. 1.—RAISING 33-FOOT DERRICKS TO AN UPRIGHT POSITION. (ORIGINAL.)

FIG. 2.—DERRICKS IN POSITION (ONE ON EACH SIDE OF TREE) SUPPORTED BY GUY ROPES; PULLEYS HOOKED TO CATCH-RINGS IN THE TENT. (ORIGINAL.)

FIG. 1.—FRONT EDGE OF SHEET TENT RAISED TO TOPS OF DERRICKS, READY TO BE PULLED OVER TREE. (ORIGINAL.)

FIG. 2.—SHEET TENT READY FOR INTRODUCTION OF CHEMICALS. (ORIGINAL.)

common in Florida, especially when the trees are closely set. After adjusting or "kicking in" the edges, the tent is ready for the introduction of the chemicals.

Whether simple poles or derricks are used, tents are usually changed from one tree to the next in the row by making the attachment as described and pulling the tent directly off from one onto the other. When there are only a few large trees to fumigate and the tents at hand are singly not sufficiently large to cover, two can be frequently used to advantage, placing them in position from opposite sides and having them overlap as much as possible without interfering with tightness at the ground.

It is best to have the tents large enough so that not less than 2 feet of the edge will rest on the ground at any point when adjusted and ready for fumigation. Sometimes it may be necessary to weight down the tents at certain points by means of a few shovelfuls of earth. Carelessness of the workmen charged with adjusting the tents at the ground would result in seriously curtailing the benefits from fumigating a grove. When arriving at the end of a row, or on other occasions when it is desired to uncover a tree without at the same time pulling the tent in position over another, the tent is usually dragged off by hand. If there is dead wood present, however, to avoid the possibility of injuring the tent, removal with the poles or derricks may be advisable. It is well to call attention again to the desirability of always pulling the tent lengthwise with the strips, whether in changing the tent from tree to tree or in dragging off from a tree after treatment.

Bell tents.—The method of covering trees with bell or hoop tents is so plainly shown by Plate I as to require but few words of explanation. The cloth should fall over the hoop on the side farthest from the tree, in order to bring the center of the tent about over the center of the tree in covering. Usually two men, one on each side, can easily throw the tent entirely over the tree, but if the tree to be covered requires nearly the full capacity of the tent it will be necessary to pass around to the front of the tree and pull the tent down into position with the hoop resting on the ground. Ordinarily the cloth which extends below the hoop makes the tent sufficiently tight at the bottom when the hoop is resting flat on the ground. An extra man with a pole or rope may be necessary to assist in handling the largest sizes of hoop tents, when they are used to cover the largest trees possible. In changing from one tree to the next in the row a little experience will show what is the quickest and easiest method. Tents of this pattern are at present little used in California, the sheet tent being greatly preferred even for small trees.

MEASURING TREES.

Necessity for measurements.—The rule followed by some California fumigators in estimating the dosage for scale insects is to give an amount which in the manager's judgment is as large as each tree will stand without injury to well-matured growth. Tender growth is almost invariably injured by a proper dosage, but this loss is not considered of consequence. In Florida, however, there is usually little or no new growth until toward the close of the season to which fumigation for the white fly should be limited. It is obviously impossible, even for an experienced fumigator, without measuring, to judge of the size of trees so accurately as to avoid overdoses, on the one hand, wasting a small percentage of the chemicals, and, on the other hand, underestimates with the consequent lack of effectiveness. The difference between an effective dosage as a treatment for the white fly and one which would produce injury to the tree is not large in many cases,[a] and careful estimation of dosage seems essential for economy and success in fumigation for this insect. Even among fumigators considered most successful in California, there is a wide diversity of opinion as to the quantity of chemicals required for trees of the same size, as shown by the observations of Mr. S. J. Hunter, reported by Professor Woodworth, and by the published recommendations as to dosage by various writers. The significance of this in California is that there is a great difference between efficiency against the scale insects treated and danger to the trees; and the practice of basing dosage on guesses as to the dimensions, either before or after covering, necessarily results in the danger of underestimation of the dosage requirement on the one hand and a needless waste of chemicals on the other. A study of the table given in the appendix, showing the dosage recommended for successful work against the white fly with untreated tents,[b] proves the physical impossibility of a fumigator approximating such dosage without a definite knowledge of the size of the space inclosed and of the ratio of the number of cubic feet of contents to the square feet of surface through which the gas gradually escapes. This can be obtained only by actual measurements. The only two dimensions which it is at all practicable to obtain are the circumference of the tented tree at the base and the distance over the top from ground to ground. The system here recommended will, by insuring satisfactory results, prove the most economical for adoption

[a] The experimental work conducted in Florida during the winter of 1907–8 has shown that the liability of injuring citrus trees from overdosing is frequently dependent upon the physiological condition of the trees as affected by the nature of the soil, the soil moisture, and the chemical fertilizers used in the grove.

[b] Water-shrunk or its equivalent as regards tightness. It should be borne in mind that mildew-proofing with tannin, etc., is not supposed to increase tightness more than does the normal shrinking.

by any citrus grower contemplating the use of fumigation for the white fly. This has been thoroughly demonstrated by the experimental work conducted in the winter of 1907–8, when, as has been stated, approximately 4,000 trees were fumigated.

Methods followed in experimental work.—The measurements of tented trees in the experiments conducted in January and February, 1907, were made by means of a tape measure attached to a reel. In obtaining the distance over in each case the end of the tape was held in one hand while the reel was thrown over the center of the tent and the measurement made from ground to ground. For the purposes of the experiments, accuracy being desired as far as possible, measurements were made in two directions, from east to west and from north to south. In each case care was used to have the tape pass as nearly as possible over the center of the tree regardless of the highest point. Of 72 tented trees measured in two directions, 70 per cent were found to vary 12 inches or less in the two measurements, 15 per cent to vary from 13 inches to 24 inches, and 11 per cent from 25 inches to 50 inches. The average variation was 12 inches and the maximum 50 inches. Inasmuch as it is recommended that in using the table appended hereto the number in the first column next above the actual measurement (when the actual measurement is more than 6 inches above an even number) be selected in estimating the dosage, it is evident that in nearly all cases a measurement over the top of the tented tree in one direction, together with the circumference, will show the dosage with sufficient accuracy for practical purposes. A fumigator should, however, in using the table and knowing the measurement over in one direction, make allowances in case the irregular shape of the tree makes the single measurement over the top fall short of indicating the true size.

A new scheme for obtaining measurements.—The measuring of the tented tree by means of the tape, as described, requires two men, owing to the difficulty of getting the tape over the center of the tree. Ordinarily it requires only one or two minutes at the most to obtain these measurements, but when more than a few trees are to be treated a simpler and quicker process is necessary. One man can quickly obtain the circumference by using a tape provided at the end with means for attaching to the tent, while he walks once around the tree to the starting point, unreeling the tape as needed. For attaching the tape to the tent some form of metal clamp, such as is usually found in stock at gentlemen's furnishing stores, is suggested. In fumigating on a large scale the use of a tape causes considerable trouble, owing to unavoidable tangling and misplacing, especially when used at night. One of the operators, however, should always estimate the circumference of the tented tree by pacing. This can not be done with sufficient accuracy without considerable preliminary

experience—obtained by measuring the first ten or fifteen trees covered, both with the tape and by pacing, and comparing the results. In pacing, the actual distance traveled will of course always be greater than the circumference as measured by the tape. With a little experience the proper allowance can be estimated with sufficient accuracy.

For obtaining the distance over the top of the tented tree the author has devised a plan which will so simplify the careful estimation of dosage in conjunction with tables such as the one presented in the appendix that a far greater uniformity of results and important saving of materials will follow its adoption. This method consists in marking the tent as shown in figures 6 and 7 and in Plate VII. The tent is first thoroughly water-shrunk, after which from one to three entire conspicuous lines are painted lengthwise of the tent for the length of the full-length strips, and one line at right angles to longitudinal line or lines.

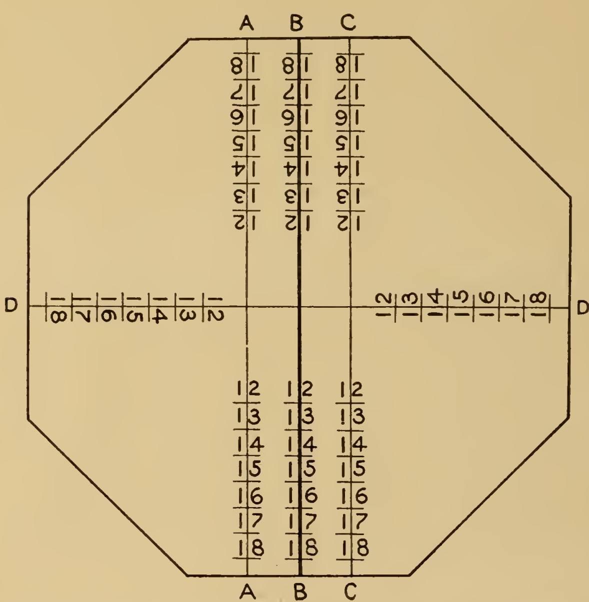


FIG. 6.—Diagram showing method of marking tents to aid in obtaining dimensions of inclosed space when covering tree: *AA*, *BB*, *CC*, parallel lines painted lengthwise with the strips of cloth from one "end" of the tent to the other; *DD*, cross-line passing through center of tent at right angles to other three. [Figures on lines *AA*, *BB*, and *CC* represent the distances in feet from the line *DD* and figures on *DD* represent distances from line *BB*. For the purposes of the diagram these distances are not proportional to the size of the tent.] (Original.)

For bell tents and sheet tents up to about 35 feet in diameter, one line running lengthwise of the strips will be sufficient, although three are preferable. For larger sheet tents three lines should always be made. The tent may be water-shrunk, if not already so, by allowing it to become wet with dew or other means, after which it should be thoroughly dried in the sun. The entire tent, or at least the central section of full-length strips, is spread flat on the ground, and the middle strip with the proper location for a median line is located. This line should be painted with a good quality of black paint[a] (flexible paint preferable) about 2½ or 3 inches wide. If three lines are

[a] Paints containing linseed oil should be avoided.

FIG. 1.—EIGHTY-FOOT TENT COVERING LARGE SEEDLING ORANGE TREE, SHOWING TENT GRADUATED FOR THE PURPOSE OF ENABLING OPERATORS TO USE DOSAGE TABLE GIVEN IN THE APPENDIX. FIG. 2.—CARRYING 5-GALLON CROCKS CONTAINING ACID AND WATER UNDER THE TENT, PREPARATORY TO INTRODUCING THE CYANID. (ORIGINAL.)

needed, another one is painted on each side of this line at a distance of about 36 inches for tents 60 feet or less in diameter and from 42 to 48 inches for tents of larger size. These two lines should not be more than 1 inch in width, so that they can be readily distinguished from the wider median line. The exact center of the tent is now located by measurement on the median line and the corresponding points on the two outside lines are marked. Taking into consideration the smallest tree that the tent probably will ever be used to cover, distances are measured on these three lines, in both directions from the center, so that parallel lines about 4 inches long, ½ inch wide, and 1 foot apart can be made across each longitudinal line, beginning 1 foot from the edge of the tent

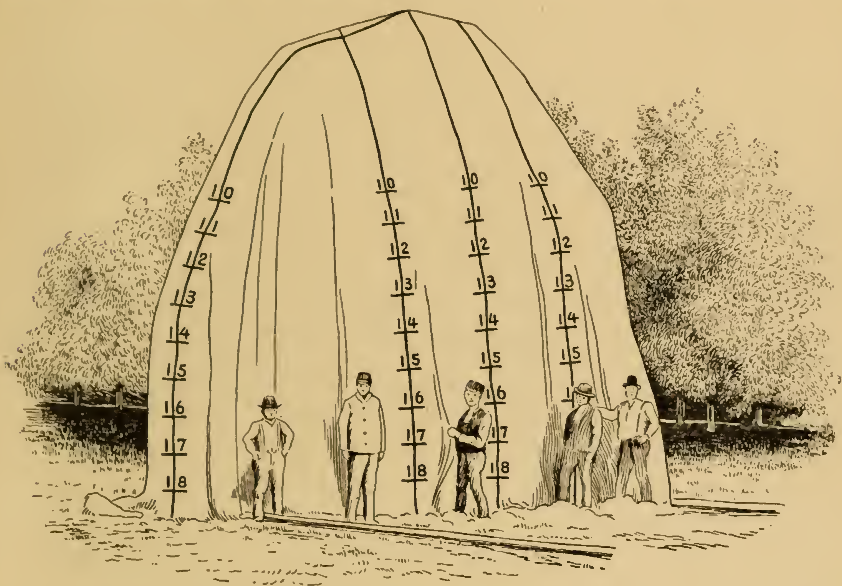


FIG. 7.—Tent marked to aid in estimating dosage, in position for fumigation. (Adapted from Marlatt.)

and making the lines in succession toward the center. After making a given number of these cross lines on each longitudinal line, the number in each case equal to the distance from the middle point to the cross line is painted on with conspicuous figures. (Pl. III, figs. 3, 4, 5, and 6; Pl. IV, fig. 1; Pl. VII, figs. 1 and 2.) If properly marked according to these directions, the corresponding cross lines on the three parallel longitudinal lines should be marked with the same number, as shown in figure 6. When the tent is exactly centered over a tree the reading at the ground on both sides of the tent will be the same. Ordinarily, however, when the tent is so placed that this line passes as nearly over the center of the tree as it is

possible to estimate, the readings will differ by 2 or 3 feet, often more. As the tent should always be pulled lengthwise of the strips, the central line will most often lie over the center of the tree, and hence be most useful in obtaining the distance over from ground to ground. Frequently, however, this measurement of the tented tree can be best obtained by selecting for the purpose one or the other of the outside lines. The distance over the top in all cases is the sum of the two readings on the line selected. The fourth line, painted at right angles to the three running lengthwise, passing through the middle point of each, extending to the sides of the tent and marked with the distances corresponding to those on the first three lines, will be of advantage when a tree is so irregular in form that one line passing over the center of the tree seems to fail to give the measurement with sufficient accuracy. When it is necessary to use this line the tent can be readily pulled directly forward or backward whatever distance is necessary to bring this line as nearly as possible over the center of the tree, leaving the longitudinal line (previously selected as the one passing most nearly over the center) in the same relative position as before. The average of the readings on the two lines will give the desired dimension as nearly correct as is necessary. Measurements of a few such irregular trees will assist the operator's judgment until his experience is sufficient to enable him to estimate the allowance in ordinary cases when necessary. The tables appended, however, give a margin above the average requirements which will cover ordinary cases of variation from the regular forms.

When a single longitudinal line is used on the smaller sized tents this line can be readily brought to any desired position by pulling sidewise on the tent, without the risk of damage by ripping at the seams, as with the larger sizes. The lines, in addition to their usefulness in estimating the dosage, will be found of considerable assistance in locating the catch rings, and in other ways, when handling the tent.

Previously proposed schemes for marking tents to aid in estimating dosage.—The idea of marking the tents to aid in determining the dose is not a new one, for in California several years ago a tent was invented which was marked with concentric rings, at each of which a dose was indicated. This failed to take into consideration the variation in circumference of tented trees whose distance over is the same. Professor Woodworth has suggested a system of marking tents, concerning which he says: [a]

It consists in making a series of parallel lines near two opposite edges of the tent, which are so distanced from the center point that they shall correspond with the dosage of a tree of the average shape. Upon these lines will be placed numerals,

[a] Bul. 152, Cal. Agr. Exp. Sta., p. 15.

indicating the dose, the circumference in yards (paces), and the difference (that is, the amount the dose must be varied) should the distance around be more or less than the amount indicated for an average tent.

This suggestion in regard to the marking of tents with the dosage to obviate the use of printed tables seems to the writer to be of considerable value under some circumstances. One objection to the use of differentials in this manner is that the cubic capacity and dosage does not increase in direct proportion to the increase in circumference with a given distance over the top. To illustrate the method of marking the tents with the dosage, when desired, a tent measuring 30 feet over from ground to ground will serve as an example. The table in the appendix shows that for every 5 feet of difference in the measurement of the circumference of a tent measuring 30 feet over the top, the amount of cyanid is increased or decreased one-half ounce, or 0.1 ounce for each foot. With the figure 30 on the tent, we would place the dosage of a tented tree measuring 30 feet in circumference. The dosage called for by the table for a tent of this size (30 by 30) is 9½ ounces. Following this the differential, or 0.1 ounce, is placed. The entire directions for obtaining the dosage would read 30—9½—0.1. A tented tree measuring 30 feet over and 38 feet in circumference would require 9½ ounces plus 0.8 ounce or, for practical purposes, 10½ ounces. If the measurement was 30 feet over and 25 feet in circumference, the dosage would be 9½ less 0.5 ounce, or 9 ounces.

When tables are worked out in detail, as they should be where accurate work is desired, reference to them is undoubtedly by far the quickest and safest method under ordinary circumstances.

METHOD OF GENERATING THE GAS.

In order to permit of making the measurements of tents and estimating the dosage with the care hereafter recommended and with the least possible delay, it is sometimes advisable, in operations on a large scale, that the cyanid be weighed during the day or at other times when it is not advisable to fumigate, or, if done at night, that an additional helper be employed. Such a helper, in addition to weighing the cyanid, might look after the replenishing of the stock of cyanid and acid at the cart as needed and assist in measuring the tents and emptying the generating jars. The cyanid should be weighed up in lots of ½, 1, 2, 5, 10, and 20 ounces, put into paper bags of convenient size, and protected from dampness. When the tented trees all measure less than 34 feet over the top from ground to ground, the doses of 20 ounces each will not be required, and when measuring more than this the lots of one-half ounce may be dispensed with. At the cart, drag, or tray these bags of cyanid should be kept in separate boxes, or in separate compartments of a

large box, and selected as needed to make up the proper dosage for the trees as they are fumigated. It has been the writer's experience that the better plan is to weigh up the chemicals in the field as fast as the dosage for the successive trees is determined. Three times as many ounces of water (liquid measure) as of cyanid is first poured into the jar. It is unnecessary to be exact in this measurement, and a long-handled dipper of 16 ounces or 1 pint capacity is preferable to the glass graduate. If, for example, 36 ounces of water are required, two and one-fourth dipperfuls are poured into the jar, dipping from the pail carried with the commissary tray. As many ounces of acid as cyanid to be used is measured in the graduate, being poured from one of the pitchers which are carried in one end of the commissary tray (Plate IV, fig. 1).

Another member of the crew in the meantime arranges for the proper dose of the cyanid and, with a lantern in hand when necessary, raises the edge of the tent while the one who measures the acid and water pours the acid into the jar containing the water, carries the cyanid and generating jar under the tent (Plate VII, fig. 2), and at arm's length empties in the cyanid. The jar should be placed about halfway between the base of the tree and the edge of the tent. For each 8 or 10 ounces of cyanid the generating jar should have a capacity of 1 gallon. For very large seedling trees two 3-gallon, 4-gallon, or even 5-gallon jars may sometimes be needed, while at other times one 3-gallon jar and one 2-gallon jar will be required for single trees, although to avoid errors it is preferable to divide the dose evenly between the jars when more than one are used. When two jars are used, they should be placed one on each side of the tree. The operator holds his breath, as soon as the cyanid is dropped into the generator, and as soon as he is outside the edge of the tent is dropped into place, while the violent boiling of the chemicals, as the gas is generated, can be distinctly heard for several minutes. The cyanid should be added as soon as possible after adding the acid, for the heat evolved by the acid and water at the time of mixing is necessary for the rapid generation of the gas. The man who measures the acid and generates the gas should have his hands protected by loose-fitting rubber gloves and should avoid being too close to the jar when pouring in the acid. He should never touch the tent while wearing the gloves unless they have been thoroughly rinsed in water.

WORK ROUTINE.

The systematic arrangement of the details of the procedure is of great importance in fumigation. The plans of work vary considerably with different fumigators, but it is the purpose in all cases to follow such work routine as will keep all hands constantly employed. In California from two to six men are employed in each outfit accord-

ing to the size and number of the trees. For medium-sized trees requiring tents not larger than 44 feet in diameter, five men can work to advantage. This crew can handle 30 tents every forty-five minutes and can treat from 350 to 400 trees in a night's work of ten hours. For trees requiring larger tents, which are shifted by means of uprights, a crew of five or six men is needed to handle about 12 or 15 tents every forty-five minutes, or between 100 and 150 trees in a full night's work. This rapidity is attained when the trees are regularly set and properly spaced and when the schedules showing the dosage for each tree to be fumigated are prepared during the day, or when the dose is based upon the judgment of the fumigator after the tent has been placed in position. As has been stated, the plan of work commonly followed in California in treating scale insects, as far as the estimation of dosage is concerned, can not be recommended for use against the white fly in Florida. The method of estimating the dosage herein recommended at the most affects the schemes of routine previously followed in fumigating only by adding an extra man to the crew. One man can calculate the dosage faster than two men can weigh out the chemicals and generate the gas. The extra expense of an additional man is entirely negligible considering the increase in efficiency on the one hand and the check on unnecessary waste of the chemicals on the other.

Barrels of water should be placed during the day at convenient points in the grove, as should also carboys or large jugs containing the acid. The tents are taken to the end of the rows, unrolled, and placed in position for covering the first trees. The cart with its supply of acid and cyanid is located near the end of the row of tents, and everything is put in readiness to start work by sundown if the wind is not so strong as to interfere. Each man in the crew has definitely assigned duties. The men who handle the poles or derricks are commonly known in California as "tent pullers," or "tent men." These men, with their one or more assistants, proceed to pull each tent in succession over the first trees of the row. If one tree should be missing, the tent is left unused during the first period rather than to break the line by moving it at once to the second tree. As each tree is covered, each one of the tent men, after disconnecting his pole or derrick, walks halfway around the tent, pulling in the edges so that it will not spread out to inclose unnecessary space. A tent after being pulled in at the bottom is shown in Plate VI. After reaching the end of the row the tent men return to the cart or commissary tray and assist in generating the gas. As soon as the first tent is in position the foreman with a lantern in hand, except when the light from the moon is sufficient, notes the position of the tent with respect to the center of the tree, using as guides the lines heretofore described. The reading is made where the selected line touches the ground.

He notes on the scratch pad the first reading and paces around the tent, noting on the pad the reading on the opposite end of the selected line. Upon reaching the starting point the distance over and the circumference—as, for example, 38–44—are noted at once upon the diagram (fig. 3, *D;* figs. 4, 5). The dosage table is referred to and the amount of cyanid to be given is noted in the diagram below the figures noting the dimensions. The foreman or the man who determines the amount of chemicals then assists in measuring and introducing the chemicals, or if two other men are available for this work he proceeds to the next tree and determines the dosage as before.

The supply of water and chemicals for the set of tents is moved ahead as fast as the generating of the gas is started under each tree. The assistant, when working on the second set of trees, picks up the generating jars beneath the first trees recently fumigated and midway between the rows scoops out a hole with his foot or with a spade and buries the contents of the jar. The foreman should never trust any responsible part of the operation to an assistant whom he does not know to be reliable. He should thoroughly systematize the work so that no unnecessary hands will be employed while at the same time his entire outfit of tents will be utilized to the best advantage.

ESTIMATION OF TIME REQUIRED FOR FUMIGATION OF GROVE.

When two men can conveniently shift the tents, they can cover a tree, take the measurements, and generate the gas without difficulty in about five minutes when not hampered by irregularities in the location of trees. This means that two men should be able to handle 9 or 10 tents in forty-five minutes with the methods herein recommended. Allowing fifteen minutes each hour for rest and restocking of the commissary tray with chemicals, two men beginning at 4 p. m. could fumigate about 75 trees by midnight. Three men in the same time could easily fumigate 100 or 115 trees somewhat larger in size, or at the rate of 13 or 14 tents every hour. Four or five men should be able to fumigate each hour from 20 to 25 trees as large as can conveniently be covered by means of changing poles. When uprights are used a crew of six men, or possibly in some cases as many as eight, can work to best advantage. Such a crew should handle from 10 to 15 tents 50 feet in diameter, or larger, every hour, including time for rest and restocking cart or tray with the chemicals.

With three men attending to determining the dosage and generating the gas and two men shifting the tents, the trees being 12 to 15 feet high, the author with other agents of the Bureau in experimental work on one occasion fumigated 19 trees in thirty-five minutes. In one night a crew of six men have fumigated 221 budded trees varying from 12 to 16 feet in height. In this case certain irregularities in the plan of setting the grove prevented a much better record.

In undertaking the fumigation of a large grove the citrus growers should avoid underestimating the hindrance to the work through winds and rains. Fortunately during the season for fumigating in Florida there is comparatively little rainfall in ordinary years. In the central section of Florida winds at night will ordinarily interfere very little, but in sections near the coast interference from this source may be more frequent. From the middle of December until the middle of February it is well to make allowance for an average of two nights each week when fumigation work will have to be suspended.

In fumigating seedling trees 30 feet or more in height one could expect to fumigate from 300 to 400 trees a week with an outfit of 8 or 10 tents. In fumigating trees from 15 to 20 feet high with an outfit of 20 tents one could expect to fumigate from 800 to 1,000 trees a week. In the cases of both the large and the small trees these estimates can frequently be exceeded when conditions are favorable, but as the period for fumigating is so limited it is advisable to avoid underestimating the time required to complete the fumigation of a grove. In planning for the necessary equipment it is safe to calculate that with one tent for each 100 trees the work of fumigation can be completed in between ten and fourteen nights' work. In many cases it is necessary to have two complete outfits at work in the same grove when the work is started late in the season and there is danger of new growth appearing on the trees before one outfit could finish the grove.

METHODS OF COMPUTING APPROXIMATE DIMENSIONS AND CUBIC CONTENTS.

The dosage recommended in the table given in the appendix is based upon detailed records of 100 trees fumigated by the writer and his assistants during January and February, 1907. Heretofore tables of this kind have been based on the height and diameter of the trees, with the exception of one prepared by Prof. C. W. Woodworth, who first recommended a dosage system based on the dimensions of the tented trees. The two dimensions of practical importance are the circumference and the distance over the top from ground to ground. The method for obtaining these dimensions has been described. In Professor Woodworth's table of dosage referred to above, the amount of cyanid was directly proportional to the cubic contents. The table of dosage here recommended is based upon actual experience and is, as far as known to the writer, the first to take into consideration the effect of leakage. Tented trees are always more or less irregular and any attempt to calculate the volume of the space inclosed can give only approximate figures. A cylinder surmounted by a hemisphere is the regular figure that is nearest to the form of a tented tree. The leakage surface of a flat octagonal tent covering a tree obviously is not

the same as the surface area of such a figure, but rather the area of a circle with a diameter equal to the distance over the top of the tent from ground to ground. To a certain extent the folds in a tent when in position over a tree reduce this surface, but this is a factor of little consequence, as it is present in all cases, and the portion of the tent folded so as to prevent all leakage represents only a small percentage of the whole. For practical purposes, therefore, the leakage surface is calculated from the mathematical formula 3.1416 multiplied by the square of the radius or πR^2. The approximate height of the tented tree can be calculated from the following formula, in which C represents the circumference of the tent at the base and O represents the distance over the top: $H = \frac{C/\pi}{2} + \frac{O - C/2}{2}$.

The diameter is found by dividing the circumference by 3.1416. The height and diameter having been obtained, the cubic contents of the regular figure mentioned can be calculated by the following formula: $\pi R^2 \left(H - \frac{R}{3}\right)$. The actual cubic inclosure of a tented tree will obviously always be more or less smaller than the regular figure to which this formula applies, although irregularities in shape will have a tendency to counteract one another.

DOSAGE REQUIREMENTS FOR THE WHITE FLY.

EXPERIMENTS WITH SHEET TENT.

Summary of results with regard to dosage.—In experiments to determine the dosage requirements for the white fly when using sheet tents, detailed records were made concerning each tree fumigated during the first season's work,[a] including every factor which might influence the results. The main objects in view in conducting the experiments were to determine the minimum dosage requirements for destroying the white fly larvæ and pupæ, the rate of leakage of the gas through the cloth, the effect of moisture on efficiency of the treatment, the effect of the treatment upon the foliage under various conditions of moisture, the margin as to dosage between effective treatment for the insect and danger to the tree, and the effect of different proportions of water and acid. Observations on other points, such as effect of wind, sunlight, condition of foliage as affected by drought, etc., were made as opportunity afforded. All the experiments were conducted between January 12 and March 1, 1907, inclusive, but observations as to results were continued for several weeks after the latter date. During this period practically

[a] The results of the experimental work during the winter of 1907–8 substantiate the conclusions derived from the work of the first season so far as the data up to this time completed show.

all the immature white flies were in the pupal stage. Of the many thousands of specimens examined in the course of the experiments, less than five were in earlier stages. The principal experiments were conducted in the grove at the laboratory in Orlando, Fla., but cooperative experiments were conducted on a larger scale in an extensive grove in the western portion of Orange County. The detailed records concerning the efficiency of fumigation against the white fly refer to experiments conducted at Orlando. A group of trees was selected for treatment on account of the comparative abundance of the live insects. As it was considered desirable to examine the insects both before and after treatment, leaves were selected at various distances from the ground, and in various sections of the tree, and the number of live and apparently normal pupæ was noted on a tag which was left attached to each leaf. After fumigation examinations were made at intervals of a few days until the appearance of the pupæ on the tagged leaves showed, beyond doubt, that the insects were dead or, if unaffected, until the evidences of normal vitality were unmistakable or the adult insects had emerged.

The acid used in the experiments, with the exception of experiments Nos. 45.37, 60.21, X.7, and X.8, was tested with a Beaumé hydrometer and found to be 66°, as guaranteed by the manufacturers. The potassium cyanid was guaranteed to be 99 per cent pure. A sample was analyzed in the Bureau of Chemistry of the Department of Agriculture and it was reported to contain 40.59 per cent cyanogen, a little more than 0.5 of 1 per cent more than that theoretically present in chemically pure potassium cyanid, the excess being due to a trace of sodium cyanid.

As has been previously stated, the sheet tent used was made of the brand of 8-ounce duck which is most used in California for fumigating tents. The tent was untreated but was thoroughly shrunk by exposure to heavy dews and therefore as tight as those ordinarily used.

A system of numbering the experiments was adopted which indicates the length of exposure and consecutive number of the tree treated for the particular duration of time. The number before the decimal point indicates this exposure for sixty minutes and less. Exposures ranging from one and a half to three hours are indicated by the letter X preceding the decimal point.

Table IV summarizes the data based upon the experiments of January and February, 1907, concerning dosage for the white fly, including for convenience the dosage called for by the tables found in the appendix.

TABLE IV.—*Summary of dosage experiments with sheet tent constructed of 8-ounce duck.*

Experiment No.	Measurements of tented tree.		Amount of cyanid used.	Per cent of white flies destroyed.	Amount of cyanid recommended in table given in appendix; 45 minutes' exposure.
	Distance over.	Circumference.			
	Feet.	*Feet.*	*Ounces.*		*Ounces.*
20.1	45	57	16½	91.9	29½
30.1	50	60	7	31	35½
30.2	44	58½	11	66	28
30.4	47	62	18	92	33
30.5	39	50	16½	98.6	20
30.6	46	56	20	71	29
30.7	40½	56	30	100	24
30.8	38	48	25¾	100	18½
40.1	44	53	5	31	25½
40.2	41½	59	10	84	26
40.3	42½	60	15	85	27
40.4	45	56	21	80	28½
40.6	39	54	17½	88	21
40.8	44½	58½	17¼	97	29½
40.9	43½	56	12	93	27
40.10	38	46	13½	95.7	17½
40.11	45½	63	25	99.2	32½
40.12	51½	64	30¾	98.4	41
40.13	44½	57	24	100	28
40.14	43½	54	26¼	100	26
40.15	37	48	21	100	18
40.18	43	54	32	100	25
40.20	43	60	32	100	27
40.21	47½	56	38	100	31
45.1	37	47	21	100	17½
45.3	47	51½	22	99.5	28
45.4	45	57½	23	100	28
45.5	46½	60½	26½	98.9	32
45.6	43½	56	22½	100	26½
45.7	50½	56	36	100	34
45.8	44½	58	27	100	28
45.9	36½	48	21	100	17
45.10	45½	67	35	100	34
45.12	34½	43	15¾	100	14
45.13	31½	38	11½	100	11½
45.15	40½	50	26¼	+99.6(?)	21
45.17	37	45	21	100	16½
45.19	31½	39	14¼	100	11½
45.20	33	50	12½	99.5	15
45.21	31	42	9	89.3	11
45.22	38	46	13¾	99.8	18
45.23	46½	56	29½	100	29½
45.24	34½	47	15½	100	15
45.25	48½	57	33½	100	32
45.26	33	46	13	100	14
45.27	46½	65	36½	+99.7(?)	34
45.28	46½	50	24½	99.5	26½
45.30	29½	30	6	100	9½
45.33	34½	36	10	100	14
45.34	40½	44	21	100	19½
45.35	40½	47	20	100	19½
45.36	45	50	20½	97.7	25
45.37	35	50	19¼	92	16½
50.1	44	58	23	66	28
50.2	39½	46½	28	100	19
50.5	52	56	37	100	35½
60.1	51	60½	30½	98.6	38
60.2	43	56	22	100	26½
60.4	44½	58	23½	100	29
60.5	38½	50	16½	100	20
60.6	33½	38	8½	97	13
60.7	38½	56	18	94	22½
60.19	41½	58½	27½	100	26½
60.20	29	37½	8½	66	10
60.21	41	55	25	97.6	24
X.1	43½	56	22½	96.7	26½
X.3	47½	54	28½	99.6	30
X.4	34	49	15	99.8	15½
X.5	47½	54	24½	99.7	30
X.6	45½	53	17¼	98.8	27½
X.7	49	62	40	[a] 99.8	37
X.8	52½	64	35½	[b] 94	42

[a] One pupa apparently alive 24 days after fumigating; 738 dead.
[b] 200 examined; 188 killed, 12 alive.

Deductions concerning effective dosage.—In formulating a definite table of dosage requirements from the above experiments the most significant results are those in which the amount of cyanid used was sufficient to destroy all but a very small percentage of the insects. Table V gives more complete data concerning the foregoing experiments, in which from 95 to 99.9 per cent of the insects were killed; also, for comparison, it gives the dosage called for by tables prepared by the author.

TABLE V.—*Data concerning dosage in those experiments in which 95 to 99.9 per cent of white flies were destroyed.*

Experiment No.	Measurements of tented tree. Distance over.	Measurements of tented tree. Circumference.	Approximate capacity of inclosed space.	Approximate leakage surface	Ratio of leakage surface to cubic contents.	Amount cyanid used.	Rate: Number cubic feet per ounce cyanid.	Amount cyanid recommended in table given in appendix	Rate: Number cubic feet per ounce cyanid recommended.
	Feet.	*Feet.*	*Cu. ft.*	*Sq. ft.*		*Ounces.*		*Ounces.*	
30.5	39	50	2,448	1,075	1:2.28	16½	148	20	122
40.10	38	46	2,080	1,134	1:1.83	13½	154	17½	119
40.8	44½	58½	3,584	1,554	1:2.30	17¼	207	29	123
40.11	45½	63	4,290	1,625	1:2.65	25	171	32½	131
40.12	51½	64	5,338	2,082	1:2.56	30¾	174	41	130
45.20	33	50	1,862	855	1:2.17	12½	149	15	124
45.22	38	46	2,080	1,134	1:1.83	13½	154	17½	119
45.36	45	50	3,046	1,590	1:1.88	20½	148	25	122
45.28	46½	50	3,194	1,697	1:1.88	24½	130	26½	120
45.5	46½	60½	4,238	1,697	1:2.49	26½	160	32	132
45.3	47	50½	3,397	1,734	1:1.95	22	154	28	121
60.6	33½	38	1,297	881	1:1.47	8½	152	13	100
60.21	41	55	3,027	1,320	1:2.29	[a] 25	121	24	126
60.1	51	60½	4,867	2,042	1:2.38	30½	160	38	128
[b] X.4	34	49	1,890	908	1:2.08	15	126	15½	122
[c] X.1	43½	56	3,412	1,485	1:2.29	22½	156	26½	129
[d] X.6	45½	53	3,272	1,625	1:2.01	17¼	189	27½	119
[e] X.5	47½	54	3,713	1,771	1:2.09	24½	151	30	123
[f] X.3	47½	54	3,713	1,771	1:2.09	28½	130	30	123

[a] One of several trees fumigated on night of March 1, 1907. Unsatisfactory results supposed to be due to poor quality of acid.
[b] Exposure, 1 hour and 45 minutes.
[c] Exposure, 2 hours and 50 minutes.
[d] Exposure, 1 hour and 30 minutes.
[e] Exposure, 1 hour and 35 minutes.
[f] Exposure, 1 hour and 55 minutes.

For purposes of comparison with Table V, the data on the dosage experiments in which all of the insects were believed to have been killed in forty-five-minute exposures are given in Table VI, which, like the preceding, includes the rate and amount of dosage calculated according to the dosage recommendations hereinafter given.

TABLE VI.—*Data concerning dosage in those experiments in which 100 per cent of white flies were destroyed.*

Experiment No. (series 45).	Measurements of tented tree.		Approximate capacity of inclosed space.	Approximate leakage surface	Ratio of leakage surface to cubic contents.	Amount cyanid used.	Rate: Number cubic feet per ounce cyanid.	Amount cyanid recommended in table given in appendix	Rate: Number cubic feet per ounce cyanid recommended.
	Distance over.	Circumference.							
	Feet.	*Feet.*	*Cu. ft.*	*Sq. ft.*		*Ounces.*		*Ounces.*	
30	29½	30	735	683	1:1.08	6	118	9½	77
13	31	38	1,149	754	1:1.52	11½	100	11	104
19	31½	39	1,219	779	1:1.56	14¼	84	11½	106
26	33	46	1,656	855	1:1.93	13	127	14	118
33	34½	36	1,224	935	1:1.31	10	122	13	94
12	34½	43	1,620	935	1:1.73	15¾	103	14	116
24	34½	47	1,855	935	1:1.98	15½	119	15½	119
17	36½	45½	1,888	1,043	1:1.81	21	90	17	111
9	36½	48	2,049	1,043	1:1.96	21	98	17	120
1	37	47	2,075	1,075	1:1.93	21	99	17	122
34	40	44	2,092	1,256	1:1.66	21	100	18½	113
35	40	47	2,341	1,256	1:1.86	20	117	20	117
6	43½	56	3,412	1,482	1:2.35	22½	151	26½	129
8	44½	58	3,691	1,554	1:2.37	27	136	29½	125
4	45	57½	3,732	1,589	1:2.34	23	162	28½	131
10	45½	67	4,665	1,625	1:2.87	35	133	34½	132
23	46½	56	3,556	1,697	1:2.15	29½	124	30	118
25	48½	57	4,095	1,846	1:2.21	33½	122	33	124
7	50½	56	4,275	2,002	1:2.13	36	119	34	125

These tables show that with tents of 8-ounce duck and untreated with paint or sizing there is little or no advantage in exposures of more than 40 minutes. The results with exposures of 30 and 40 minutes compare favorably with those ranging from 45 minutes to 2 hours and 50 minutes. It is evident that the gas escapes rapidly and that in the course of a period of 30 to 40 minutes at the most the gas from a dosage of maximum utility is so diluted as to be practically ineffective. On the other hand, the table shows conclusively that the experiments afford no justification for reducing the dosage on account of lengthening the exposure from 45 to 60 minutes or longer. Everything considered, the writer adopted the 40-minute period of exposure as probably affording the greatest benefit from a given amount of cyanid.

As an aid in determining the rates of dosage which could be safely recommended for the various ratios of leakage surface to cubic contents, the experiments referred to in Table V were arranged in accordance with the ratio, and in each case the writer estimated the amount of potassium cyanid which it seemed evident would have been ample for the destruction of all the insects. The degree of success obtained with the amount of potassium cyanid actually used was taken into consideration in estimating the amount needed. The data thus arranged, together with calculations of the rate, or number of cubic feet of space per ounce of potassium cyanid, are given in Table VII.

TABLE VII.—*Study of dosage rates.*

Ratio of square feet in leakage surface to cubic feet of contents.	Amount of cyanid used.	Per cent of white flies destroyed.	Amount cyanid estimated as necessary for successful results.	Rate: Number cubic feet of space per ounce of cyanid. Used.	Rate: Number cubic feet of space per ounce of cyanid. Estimated as necessary.
	Ounces.		*Ounces.*		
1:2.65	25	99.2	27	171	159
1:2.56	30¾	98.4	34	174	157
1:2.49	26½	98.9	29	160	146
1:2.38	30½	98.6	33	160	144
1:2.30	17¼	97	20	207	179
1:2.29	25	97.6	28	127	108
1:2.28	16½	98.6	19	148	128
1:2.17	12½	99.5	14	149	133
1:2.09	24½	99.7	27	151	138
1:2.09	28½	99.6	30	130	124
1:2.08	15	99.8	16	126	118
1:2.01	17¼	98.8	20	189	163
1:1.95	22	99.5	24	154	141
1:1.88	24½	99.5	27	130	118
1:1.88	20½	97.7	24	148	127
1:1.83	13½	99.8	15	154	138
1:1.83	13½	95.7	17	146	122
1:1.47	8½	97	11	152	118

From a study of the data in the Table VII the writer concluded that for a ratio of 1:1.5 the cyanid should be used at a rate very near to 1 ounce to 110 cubic feet of space. Owing to the fact that in all cases tented trees include less inclosed space than would a regular figure which for purposes of approximate calculations has been considered as equivalent, this rate would be higher for a regularly shaped inclosure whose cubic contents could be definitely calculated. Probably 1 ounce to 100 cubic feet of space is nearer the actual rate which the experiments indicate is necessary with the ratio mentioned. This, however, is of little consequence in dealing with sheet tents, for only the comparative volumes and dosage rates for trees of different dimensions are required for practical purposes. Having decided upon the adoption of 1 ounce of potassium cyanid per 110 cubic feet of space with the ratio of 1:1.5, calculations were made for tents with different ratios up to 1:3.6. Professor Gossard reports[a] that 1 ounce to 170 cubic feet of space destroys all white fly pupæ in an air-tight fumigatorium. Considering that this rate is approximately correct, an equivalent rate for the volume inclosed by a sheet tent covering a tree would be more than 170 cubic feet in the ideal form of inclosure upon which the calculations are based. Experiments numbered X.3 and X.4, however, show that a rate not less than 1 ounce for 126 cubic feet of space should be used when the ratio is 1:2. When the ratio is increased from 1:1.5 to 1: infinity[b] and the rate of dosage for this latter ratio is considered as 1 ounce

[a] Fla. Exp. Sta. Bul. 67, p. 652.

[b] It is evident that if the number of cubic feet of space were infinitely greater than the number of square feet of leakage surface, the rate of dosage required for an air-tight fumigatorium would be sufficient.

for 170 cubic feet of space, all of the rates are more or less greater than those used in the experiments in which from 95 per cent to 99.9 per cent of the insects were killed. It is evident that the increase in number of cubic feet per ounce of potassium cyanid from 110 to 170 must be calculated at a rate which is in direct proportion to the percentage of increase in cubic contents. The method employed in these calculations is shown in Table VIII, which gives the figures with the ratios ranging from 1:1.0 up to 1:3.6.

TABLE VIII.—*Rates of dosage as affected by ratio of number of square feet in surface to the number of cubic feet in volume.*

Ratio.	Per cent of increase in cubic contents.	Number of cubic feet per ounce cyanid.	Difference between number cubic feet per ounce and 170.	Increase in number cubic feet per ounce cyanid.	Ratio.	Per cent of increase in cubic contents.	Number of cubic feet per ounce cyanid.	Difference between number cubic feet per ounce and 170.	Increase in number cubic feet per ounce cyanid.
1:1	....	76.8	93.2	....	1:2.4	4.34	133.5	36.5	1.7
1:1.1	10	86.1	83.9	9.3	1:2.5	4.16	135	35	1.5
1:1.2	9.09	93.7	76.3	7.6	1:2.6	4	136.4	33.6	1.4
1:1.3	8.33	100.1	69.9	6.4	1:2.7	3.85	137.7	32.3	1.3
1:1.4	7.69	105.4	64.6	5.3	1:2.8	3.7	138.9	31.1	1.2
1:1.5	7.14	110	60	4.6	1:2.9	3.6	140	30	1.1
1:1.6	6.66	114	56	4	1:3.0	3.44	141	29	1.03
1:1.7	6.25	117.5	52.5	3.5	1:3.1	3.33	142	28	.97
1:1.8	5.88	120.6	49.4	3.1	1:3.2	3.26	142.9	27.1	.91
1:1.9	5.55	123.3	46.7	2.7	1:3.3	3.12	143.8	26	.85
1:2.0	5.26	125.8	44.2	2.5	1:3.4	3.03	144.5	25.4	.79
1:2.1	5	128	42	2.2	1:3.5	2.94	145.3	24.7	.75
1:2.2	4.76	130	40	2	1:3.6	2.86	146	24	.71
1:2.3	4.54	131.8	38.2	1.8					

In Table VIII the number of cubic feet of space per ounce of potassium cyanid increases toward 170, representing the rate when the ratio is 1 to infinity, and the dosage increases in rate (= decrease in the number of cubic feet per ounce of potassium cyanid) as the units of cubic contents become infinitely small in number as compared with the units of square measure of leakage surface. Using the above rates as a basis, the doses for trees measuring from 10 to 76 feet over the top have been calculated. The dimensions of the tented trees and volumes of the inclosed spaces have been calculated in accordance with the formulæ given in the preceding pages. Table IX gives the original calculations, while in the appendix the recommended doses alone are given, in a form more convenient for practical use in the field.

TABLE IX.—*Recommended dosage, with 45-minute exposures.*

Measurements of tented trees: Distance over.	Measurements of tented trees: Circumference.	Area of leakage surface.	Height of regular figure with foregoing measurements.	Diameter of regular figure with foregoing measurements.	Volume.	Ratio of leakage surface to cubic contents.	Rate of dosage, number cubic feet space per ounce cyanid	Amount of cyanid recommended.
Feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Cu. feet.*			*Ounces.*
10	15	78	3.6	4.7	48	1:0.61	....	1.0
	20	78	3.2	6.4	69	1:0.89	....	1.0
12	15	113	4.6	4.8	65	1:0.57	....	2.0
	20	113	4.2	6.4	101	1:0.89	....	2.0
14	15	154	5.6	4.8	85	1:0.55	....	2.5
	20	154	5.2	6.4	133	1:0.86	....	2.5
	25	154	4.7	8.0	171	1:1.11	76	2.5
16	20	201	6.2	6.4	165	1:0.82	62	3.0
	25	201	5.7	8.0	221	1:1.10	88	3.0
	30	201	5.3	9.5	276	1:1.37	100	3.0
18	20	254	7.2	6.4	197	1:0.77	56	4.0
	25	254	6.7	8.0	271	1:1.06	74	4.0
	30	254	6.3	9.5	347	1:1.36	102	4.0
	35	254	5.8	11.1	406	1:1.60	114	4.0
20	20	314	8.2	6.4	229	1:0.73	54	4.2
	25	314	7.7	8.0	321	1:1.02	76	4.2
	30	314	7.3	9.5	418	1:1.33	100	4.2
	35	314	6.8	11.1	500	1:1.59	112	4.4
22	25	380	8.7	8.0	372	1:0.97	75	4.9
	30	380	8.3	9.5	489	1:1.28	96	5.1
	35	380	7.8	11.1	594	1:1.56	111	5.3
	40	380	7.4	12.7	670	1:1.78	118	5.9
24	30	452	9.3	9.5	550	1:1.21	93	5.9
	35	452	8.8	11.1	688	1:1.52	110	6.2
	40	452	8.4	12.7	797	1:1.76	117	6.8
	45	452	7.9	14.3	927	1:2.05	128	7.2
26	30	531	10.3	9.5	621	1:1.17	89	7.0
	35	531	9.8	11.1	782	1:1.47	107	7.3
	40	531	9.4	12.7	924	1:1.74	118	7.8
	45	531	8.9	14.3	1,046	1:1.97	124	8.4
28	30	615	11.3	9.5	692	1:1.12	86	8.1
	35	615	10.8	11.1	876	1:1.42	105	8.3
	40	615	10.4	12.7	1,051	1:1.70	117	8.9
	45	615	9.9	14.3	1,206	1:1.96	124	9.7
30	30	707	12.3	9.5	763	1:1.08	80	9.0
	35	707	11.8	11.1	970	1:1.37	100	9.7
	40	707	11.4	12.7	1,178	1:1.66	114	10.3
	45	707	10.9	14.3	1,364	1:1.93	123	11.1
32	30	804	13.3	9.5	834	1:1.03	79	10.5
	35	804	12.8	11.1	1,067	1:1.32	100	10.7
	40	804	12.4	12.7	1,305	1:1.62	114	11.4
	45	804	11.9	14.3	1,527	1:1.90	123	12.4
	50	804	11.5	15.9	1,750	1:2.17	129	13.6
34	30	908	14.3	9.5	906	1:1.00	76	4.9
	35	908[1]	13.8	11.1	1,161	1:1.28	95	12.0
	40	908	13.4	12.7	1,433	1:1.58	112	12.8
	45	908	12.9	14.3	1,684	1:1.85	121	13.9
	50	908	12.5	15.9	1,951	1:2.14	128	15.2
36	35	1,018	14.8	11.1	1,265	1:1.24	95	13.3
	40	1,018	14.4	12.7	1,560	1:1.53	110	14.2
	45	1,018	13.9	14.3	1,844	1:1.81	120	15.3
	50	1,018	13.4	15.9	2,149	1:2.11	128	16.7
	55	1,018	13.0	17.5	2,428	1:2.38	132	18.4
38	35	1,134	15.8	11.1	1,360	1:1.20	93	14.6
	40	1,134	15.4	12.7	1,688	1:1.48	107	15.7
	45	1,134	14.9	14.3	2,005	1:1.76	118	17.0
	50	1,134	14.4	15.9	2,348	1:2.07	126	18.7
	55	1,134	14.0	17.5	2,668	1:2.35	132	20.2
40	40	1,256	16.4	12.7	1,816	1:1.44	106	17.0
	45	1,256	15.9	14.3	2,165	1:1.72	117	18.5
	50	1,256	15.4	15.9	2,546	1:2.02	125	20.3
	55	1,256	15.0	17.5	2,909	1:2.31	131	22.2
	60	1,256	14.5	19.1	3,256	1:2.59	135	24.1
42	40	1,385	17.4	12.7	1,943	1:1.40	105	18.5
	45	1,385	16.9	14.3	2,326	1:1.68	115	20.2
	50	1,385	16.4	15.9	2,745	1:1.98	124	22.1
	55	1,385	16.0	17.5	3,149	1:2.27	130	24.2
	60	1,385	15.5	19.1	3,542	1:2.55	135	26.2
44	45	1,520	17.9	14.3	2,486	1:1.63	114	21.8
	50	1,520	17.4	15.9	2,944	1:1.93	123	23.9
	55	1,520	17.0	17.5	3,389	1:2.22	130	26.1
	60	1,520	16.5	19.1	3,828	1:2.52	135	28.3
	65	1,520	16.1	20.7	4,254	1:2.80	138	30.8

TABLE IX.—*Recommended dosage, with 45-minute exposures*—Continued.

Measurements of tented trees. Distance over.	Measurements of tented trees. Circumference.	Area of leakage surface.	Height of regular figure with foregoing measurements.	Diameter of regular figure with foregoing measurements.	Volume.	Ratio of leakage surface to cubic contents.	Rate of dosage, number cubic feet space per ounce cyanid.	Amount of cyanid recommended.
Feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Cu. feet.*			*Ounces.*
46	50	1,662	18.4	15.9	3,133	1:1.88	121	25.9
	55	1,662	17.9	17.5	3,630	1:2.18	129	28.1
	60	1,662	17.5	19.1	4,115	1:2.47	134	30.7
	65	1,662	17.0	20.7	4,591	1:2.76	138	33.2
	70	1,662	16.6	22.3	5,038	1:3.03	141	35.7
48	50	1,810	19.4	15.9	3,332	1:1.84	121	27.5
	55	1,810	18.9	17.5	3,870	1:2.13	128	30.2
	60	1,810	18.5	19.1	4,401	1:2.43	133	33.1
	65	1,810	18.0	20.7	4,927	1:2.72	137	35.9
	70	1,810	17.6	22.3	5,428	1:3.00	141	38.5
50	55	1,964	19.9	17.5	4,111	1:2.09	127	32.4
	60	1,964	19.5	19.1	4,687	1:2.38	132	35.5
	65	1,964	19.0	20.7	5,264	1:2.63	136	38.7
	70	1,964	18.6	22.3	5,828	1:2.96	140	41.6
	75	1,964	18.2	23.9	6,358	1:3.24	142	44.7
52	55	2,123	20.9	17.5	4,351	1:2.05	126	34.5
	60	2,123	20.5	19.1	4,974	1:2.34	132	37.6
	65	2,123	20.0	20.7	5,600	1:2.63	136	41.1
	70	2,123	19.6	22.3	6,217	1:2.92	140	44.4
	75	2,123	19.2	23.9	6,805	1:3.20	142	47.9
54	55	2,289	21.9	17.5	4,591	1:2.00	125	36.7
	60	2,289	21.5	19.1	5,261	1:2.30	131	40.1
	65	2,289	21.0	20.7	5,936	1:2.60	136	43.6
	70	2,289	20.6	22.3	6,607	1:2.88	138	47.8
	75	2,289	20.2	23.9	7,252	1:3.16	142	51.1
56	60	2,462	22.5	19.1	5,547	1:2.25	130	42.6
	65	2,462	22.0	20.7	6,273	1:2.54	135	46.4
	70	2,462	21.6	22.3	6,997	1:2.84	138	50.7
	75	2,462	21.2	23.9	7,700	1:3.12	142	54.2
	80	2,462	20.8	25.5	8,459	1:3.43	144	58.7
58	60	2,641	23.5	19.1	5,834	1:2.20	130	44.8
	65	2,641	23.0	20.7	6,609	1:2.50	135	48.8
	70	2,641	22.6	22.3	7,396	1:2.80	138	53.6
	75	2,641	22.2	23.9	8,147	1:3.09	141	57.7
	80	2,641	21.8	25.5	8,971	1:3.39	144	62.3
60	60	2,826	24.5	19.1	6,120	1:2.16	128	47.8
	65	2,826	24.0	20.7	6,945	1:2.45	134	51.8
	70	2,826	23.6	22.3	7,786	1:2.75	138	56.4
	75	2,826	23.2	23.9	8,595	1:3.04	141	60.9
	80	2,826	22.8	25.5	9,483	1:3.35	144	65.4
62	60	3,018	25.5	19.1	6,406	1:2.12	128	50.0
	65	3,018	25.0	20.7	7,282	1:2.41	133	54.7
	70	3,018	24.6	22.3	8,176	1:2.71	137	59.6
	75	3,018	24.2	23.9	9,042	1:3.00	141	64.1
	80	3,018	23.8	25.5	9,995	1:3.31	143	69.2
64	60	3,215	26.5	19.1	6,693	1:2.08	126	53.1
	65	3,215	26.0	20.7	7,618	1:2.37	132	57.7
	70	3,215	25.6	22.3	8,565	1:2.66	136	63.0
	75	3,215	25.2	23.9	9,489	1:2.95	140	67.7
	80	3,215	24.8	25.5	10,507	1:3.26	143	73.4
66	60	3,419	27.5	19.1	6,979	1:2.04	126	55.4
	65	3,419	27.0	20.7	7,955	1:2.33	131	60.7
	70	3,419	26.6	22.3	8,955	1:2.61	134	66.8
	75	3,419	26.2	23.9	9,937	1:2.90	140	70.9
	80	3,419	25.8	25.5	11,019	1:3.22	142	77.6
	85	3,419	25.3	27.1	11,939	1:3.49	144	82.9
68	60	3,630	28.5	19.1	7,266	1:2.00	125	58.1
	65	3,630	28.0	20.7	8,290	1:2.28	130	63.7
	70	3,630	27.6	22.3	9,345	1:2.57	135	69.2
	75	3,630	27.2	23.9	10,384	1:2.86	139	74.6
	80	3,630	26.8	25.5	11,531	1:3.17	142	81.1
	85	3,630	26.3	27.1	12,513	1:3.45	144	87.5
70	60	3,848	29.5	19.1	7,552	1:1.96	123	61.4
	65	3,848	29.0	20.7	8,627	1:2.24	130	66.3
	70	3,848	28.6	22.3	9,734	1:2.53	135	72.1
	75	3,848	28.2	23.9	10,831	1:2.81	138	78.5
	80	3,848	27.8	25.5	12,043	1:3.10	142	84.8
	85	3,848	27.3	27.1	13,088	1:3.40	144	90.9
72	60	4,069	30.5	19.1	7,838	1:1.92	123	63.7
	65	4,069	30.0	20.7	8,963	1:2.20	130	68.9
	70	4,069	29.6	22.3	10,124	1:2.49	134	75.5
	75	4,069	29.2	23.9	11,278	1:2.77	137	82.3
	80	4,069	28.8	25.5	12,555	1:3.08	141	89.0
	85	4,069	28.3	27.0	13,662	1:3.35	144	94.8
	90	4,069	27.8	28.6	14,829	1:3.64	146	101.5

TABLE IX.—*Recommended dosage, with 45-minute exposures*—Continued.

Measurements of tented trees.		Area of leakage surface.	Height of regular figure with foregoing measurements.	Diameter of regular figure with foregoing measurements.	Volume.	Ratio of leakage surface to cubic contents.	Rate of dosage, number cubic feet space per ounce cyanid.	Amount of cyanid recommended.
Distance over.	Circumference.							
Feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Cu. feet.*			*Ounces.*
74	60	4,299	31.5	19.1	8,125	1:1.89	121	67.1
	65	4,299	31.0	20.7	9,300	1:2.18	129	71.3
	70	4,299	30.6	22.3	10,513	1:2.45	134	78.4
	75	4,299	30.2	23.9	11,726	1:2.72	137	85.6
	80	4,299	29.8	25.5	13.067	1:3.03	141	92.7
	85	4,299	29.3	27.0	14,237	1:3.31	143	99.5
	90	4,299	28.8	28.6	15,471	1:3.60	146	106.0
76	60	4,534	32.5	19.1	8,411	1:1.85	120	70.0
	65	4,534	32.0	20.7	9,635	1:2.12	128	75.2
	70	4,534	31.6	22.3	10,903	1:2.40	133	82.0
	75	4,534	31.2	23.9	12,173	1:2.66	136	89.4
	80	4,534	30.8	25.5	13,579	1:2.99	140	97.0
	85	4,534	30.3	27.0	14,812	1:3.26	143	103.5
	90	4,534	29.8	28.6	16.113	1 3.55	145	111.1

EXPERIMENTS WITH BELL OR HOOP TENT.

The bell or hoop tent used in these experiments was one constructed of 6½-ounce drill of the brand most commonly used in California. Owing to the form of the tent the leakage surface is far less in proportion to the volume than in the sheet tent. The data concerning the experiments and the recommended dosage based upon the experiments with the sheet tent are given in Table X.

TABLE X.—*Experiments in fumigation with bell-shaped tent of 6½-ounce drill.*

Experiment No.	Measurements of tented trees.		Amount of cyanid used.	Number of white flies under observation.	Per cent of white flies killed.	Amount of cyanid recommended in table for 45 minutes' exposure.
	Distance over.	Circumference.				
	Feet.	*Feet.*	*Ounces.*			*Ounces.*
30.3	28½	35	4	555	88	9
40.5	27	38	4	138	88	8½
40.7	33½	38	8½	132	80	13
40.16	20	23	4	300	100	4½
40.17	25½	27	7	476	100	7
40.19	24	20	4	209	100	5½
40.22	20	22	2	162	97.4	4½
45.2	28	29	7	427	100	8½
45.11	26	31½	4½	284	100	7½
45.14	31	35	10¾	289	100	10½
45.16	27½	29	6¾	431	100	8½
45.18	27	34½	9¼	595	100	8
45.29	29½	30	6	530	100	9½
45.31	23	24	3¼	376	98.7	6
50.3	24½	31½	4	128	97.6	7
50.4	34½	37	8½	990	100	14
60.8	26	31	4½	42	85.7	7½
X.2	33	35	11	200	100	12½

In these experiments a dosage sufficient to destroy all pupæ was used in eleven instances. The total amount of cyanid used in the eleven experiments was 78¾ ounces, whereas the doses recommended in the tables, based upon the experiments with the sheet tents of 8-ounce duck, together amounted to 96 ounces. The average of the amounts used in the eleven tests was 7.2 as against 8.7 recommended

in the tables. It is evident from the results summarized in the foregoing table that prolongation of the period of exposure beyond 40 minutes produces no noticeable increase in effectiveness. It is also evident that the dosage recommended for use with sheet tents of a good quality of 8-ounce duck is ample for bell tents of a good quality of 6½-ounce drill. The smaller amount of leakage surface with bell tents as compared with sheet tents may be entirely responsible for the apparently wide margin between the recommended dosage and the dosage actually required for efficiency, but it seems safe to conclude that the 6½-ounce drill used in the bell tent held the gas approximately as well as the 8-ounce duck, the difference in leakage surface considered.

MISCELLANEOUS EXPERIMENTS AND OBSERVATIONS.

APPEARANCE OF LARVÆ AND PUPÆ OF THE WHITE FLY WHEN DESTROYED BY FUMIGATION.

The opportunities for studying the efficiency of the gas against citrus pests are far superior with the white fly as compared with the true scale insects. While it requires considerable skill in the examinations, the vital conditions of the larvæ and pupæ, both before and after treatment, can be recognized with practical certainty without removing the specimens from the leaves. When in a normal condition the insects in the stages mentioned appear green, owing to their translucence, and paired yellowish spots, due to internal organs, are sometimes visible in the abdominal region. As the pupa reaches maturity the reddish eyes of the adult become conspicuous and the location of the developing adult wings is indicated by whitish patches on either side of the body. When destroyed by fumigation with hydrocyanic-acid gas the larvæ and pupæ usually turn more or less brownish in the course of a few days. This brownish discoloration is most pronounced along the middle of the body. Frequently, however, two or three weeks may elapse before they can be positively determined as dead. In the first examinations made by the author, pupæ on fumigated trees were classed as alive, doubtful, and dead. It was afterwards determined that in practically every case those classed as doubtful were in reality dead. Examinations under a compound microscope were found to be of some assistance at times, but on the whole unsatisfactory. In such cases movements of the internal organs furnish positive proof that the insect is alive, but when these movements can not be detected there may still be doubt concerning the condition of the specimen unless granulation or discoloration of the body contents is evident. The most satisfactory method of observing the results of fumigation is to examine the insects with a hand lens of 1 or 1½ inch focal distance without dis-

turbing the insect or detaching the leaf from the tree. String tags attached to leaves upon which are specimens classed as doubtful will enable examinations of such specimens from time to time until their condition is positively determined. A careful examination of normal specimens and direct comparisons of these with those on leaves of fumigated trees will assist in the ready identification of the dead insects.

DENSITY OF THE GAS AT VARIOUS HEIGHTS ABOVE THE GROUND.

It is natural to presume that owing to the fact that hydrocyanic-acid gas is lighter than air, its density during the process of fumigation is greater toward the top of the tree. In four of the nine observations on the comparative effect of the gas at different heights above ground the results of this variation in density are not evident. In the other five observations the results are quite striking. In the six experiments in which observations were made 10 feet or more from the ground, the average percentage of insects killed up to 6 feet above the ground was 64, while from 10 to 18 feet above ground the average percentage killed was 71. The data concerning the effectiveness of the gas at various distances from the ground is summarized in Table XI.

TABLE XI.—*Efficiency of gas as affected by height above ground.*

Experiment No.	Distance above ground.	Number of white fly pupæ examined.	Per cent killed.	Experiment No.	Distance above ground.	Number of white fly pupæ examined.	Per cent killed.
	Feet.				*Feet.*		
30.4	4–6	427	89	30.1	4–6	74	21
	14–15	244	98.3		12–14	909	36
	18	120	100	40.3	4–6	822	80
20.1	4–6	687	91.9		12–14	445	90.8
	12–14	1,000	90.8	30.3	2	396	92.8
20.7	4–5½	222	77		3½–7	159	78
	10	306	60	40.7	2	93	80.6
40.12	2	112	64		4–6	139	79.2
	3½–5	728	98.4				
	4–6	541	26.4				
	14–16	136	50				

The results show that when examining for the results of fumigation, the most significant effects are those within a few feet of the ground. The observations concerning the results of the experiments upon which the recommendations in this bulletin are based were made in all cases within 7 feet of the ground, and included examinations of insects on leaves closest to the ground in all cases.

EFFECT OF FUMIGATION ON THE TREES.

During the months of December, January, and February, until the appearance of the new spring growth, fumigation for the white fly with the dosage herein recommended will rarely occasion appreciable

injury to orange trees and apparently never to tangerine and grapefruit trees. The liability of injuring trees through the emptying of the contents of the jars after fumigation close to or upon the base of the trees will be referred to under the subject of precautions. The injury to orange trees from the gas itself has never in the writer's experience been sufficient to offset the benefits of destroying the white fly and scale insect pests. Nevertheless the subject is one of considerable importance. The experiments conducted in January and February, 1907, demonstrated the practicability of destroying the white fly with hydrocyanic-acid gas without injury to citrus trees.

The fumigation of nearly 4,000 trees in the winter of 1907–8 has greatly extended our knowledge of the effect of fumigation upon the trees, but there remain several unsolved problems in this connection which it is hoped will be elucidated by future experience. The work of fumigating a grove should be completed if possible before the new growth appears in the spring. Under certain temperature conditions successful fumigations may occasion no injury to new growth, but there is danger of destroying the first spring shoots which normally produce the greater part of the blooms. When affected by the gas new shoots wilt and turn dark, appearing as though affected by frost.

Under certain conditions there is more or less shedding of the old leaves following fumigation. The loss of 10 or 15 per cent of the old foliage can not be considered an injury, inasmuch as even more than this proportion is usually shed during the winter or in the spring. In fact, it has been demonstrated by experiments conducted by Mr. Yothers and the writer in February, 1908, that the leaves shed by fumigation when the percentage of the whole does not exceed 15 per cent are among the leaves which would normally drop in the course of a few weeks.

In the experiments with the sheet tent of 8-ounce duck summarized in Table IV, the most extensive shedding occurred in experiments 40.14. In this it was estimated that about 50 per cent of the leaves were shed. The tree was fumigated on January 29, beginning at 4.07 p. m., about one-half hour before sunset. No shedding was observed until the morning of February 2, when it was estimated that from 15 to 20 per cent of the leaves dropped. On February 4 it was estimated that 50 per cent of the leaves had fallen, after which date the amount of the shedding was inappreciable. The winged petioles of the leaves remained attached to the tree in most cases and the fallen leaf blades showed distinct brownish areas due to burning by the gas. The tree consisted of five stems growing from the roots of a tree frozen to the ground in 1895. One of these stems was affected by foot rot or *mal-di-gomma*, and the defoliation of this was nearly complete, materially increasing the percentage of shedding from the

tree as a whole. This tree was observed in full bloom on April 4, and ten months after the treatment appeared as vigorous as any tree in the grove and bore more than the average crop of fruit. In the experiments with the bell tent of 6½-ounce drill, shedding of consequence occurred only in the case of experiment X:2. This tree was fumigated on January 29, beginning at 4.41 and ending at 7.50 p. m. It was estimated that the shedding amounted to about 30 per cent in this case.

In experiment 45.36 the exposure began at 3.07 p. m. in bright sunlight with the temperature at 75° F. The tent had been in position for thirty minutes preceding the introduction of the chemicals, and the inside temperature was 4½° higher at the beginning than the outside temperature mentioned above. The tent was in direct sunlight during the entire forty-five minutes of exposure, and doubtless the inside temperature rose to 82° or 83°. As shown in Table IV, the amount of potassium cyanid used was 4½ ounces less than the amount recommended in the table given in the appendix. The leaves were curled as a result of drought at the time of the fumigation and no shedding of leaves or injury of any kind to the tree could be detected by subsequent examinations.

An overdose is indicated by the scorching of the foliage on entire twigs. This is more likely to occur near the tops of the trees. In such cases several twigs, each 6 inches or a foot in length, may be entirely killed, the leaves, instead of dropping within a few days, turning brown and remaining attached to the dead twig. This is not necessarily accompanied by excessive shedding of the foliage. The physiological condition of the trees seems to have a marked effect on their liability to shed foliage. Vigorous trees are less susceptible than weak, poorly nourished ones. Trees in the same grove but growing under different conditions as regards the nature of the soil and the amount of soil moisture show differences in this respect. In most groves trees will not shed leaves excessively if the dosage is increased 25 per cent above the recommended amounts. Frequently there will be no shedding at all following such a course. In other citrus groves the recommended dose is as large as the trees will stand without shedding to an injurious extent.

The likelihood of damaging citrus fruits by fumigation is such that it is strongly advisable to pick the crop before starting to fumigate. In January, 1908, many seedling trees were fumigated which held from five to eight boxes of oranges per tree, without any injury whatever following the treatment. In other cases a small percentage of the fruit developed sunken areas or "pits" which turned dark and ruined the affected fruit for shipping purposes. Fumigation in midwinter, using the dosage table given in the appendix, does not seem to affect the fruit of Hart's Lake, Lamb's Summer, or Valencia

varieties. Grapefruits are slightly susceptible to this injury, while tangerines appear not at all susceptible, although considerable shedding of the fruit occurred in one instance when the recommended dosage was doubled.

SUGGESTIONS FOR THE FUMIGATION OF SMALL TREES.

IN THE GROVE.

In discussing the style of fumigating tents desirable for use against the white fly the author has referred to the advantages of the use of box covers for small trees. In many cases complete defoliation of the trees during the winter months would be the best method of checking the pest, but fumigation is preferable under most circumstances. The dosage with box covers will depend upon the tightness of the cloth used. It has been recommended that the cloth be made as nearly air-tight as possible by means of paint, or that air-tight oilcloth be used. The rate of dosage can be readily determined by means of a series of tests, beginning with 1 ounce of potassium cyanid for each 170 cubic feet of space (0.00588 ounce per cubic foot) and decreasing the number of cubic feet per ounce 10 feet for each experiment until the results are satisfactory and uniform. No experiments have thus far been conducted by the author along these lines, but it is expected that in the course of the investigations of the white fly now under way in Florida this phase of white fly control will be given consideration.

IN THE NURSERY.

Several square yards, including many trees, can be covered in the nursery by a single tent. If the cloth is unpainted, the dosage for a first trial can be calculated by first determining the ratio of the leakage surface to the cubic contents and referring to Table VIII in this bulletin, where the recommended rate of dosage will be found for the various ratios. The results of the preliminary tests should be carefully observed before fumigating on a large scale, in order that the rate of dosage may be adjusted to suit the tightness of the cloth used as a cover.

NURSERY STOCK FOR SHIPMENT.

Prof. H. A. Gossard, formerly of the Florida experiment station, has determined that in an air-tight fumigatorium 1 ounce of potassium cyanid for each 170 cubic feet of space[a] is sufficient to destroy all

[a] "One gram to 6 cubic feet of space," he reports, "seemed sufficient to kill everything, but to make the dose more certain 1 gram to $5\frac{3}{4}$ cubic feet was adopted as the standard dose and has been repeatedly tried, always giving the uniform result of killing all larvæ (pupæ) and adults."—Bul. 67, Fla. Exp. Sta., p. 652. One ounce is equal to 28.35 grams, from which it is calculated that 1 gram for 6 cubic feet of space is equal to 1 ounce for 170 cubic feet and 1 gram for $5\frac{3}{4}$ cubic feet is equal to 1 ounce for 163 cubic feet.

larvæ and pupæ of the white fly. To destroy the eggs, however, he found that a larger dose was necessary. The author fully concurs with Professor Gossard in his recommendation to defoliate completely all white fly infested nursery stock before shipping, and, as an extra precaution, to fumigate. The almost invariable experience of Florida nurserymen, however, shows that citrus trees should not be fumigated with roots bare. The fumigation is far less necessary than when the insects concerned are true scale insects and are attached to the stems. White flies have never been known to reach maturity except on the leaves, although eggs and crawling larvæ may occasionally be found on young growing shoots. It is safe to presume that there are no unhatched eggs of the white fly on anything other than leaves and young succulent growth of stems. When these are completely removed there need be no fear that the pest will be carried by means of the trees. The entire leaves, including the winged leaf petioles, must be removed, and when large shipments are concerned careful attention must be given to this. A greater danger than the trees themselves is found in the packing. This, as Professor Gossard points out, might be a possible source of danger if infested citrus leaves were allowed to get into the moss or other material used in packing. The danger is, of course, slight, but should nevertheless be borne in mind by shippers and buyers of nursery stock.

PRECAUTIONS.

As is customary in publications on entomology in which the use of potassium cyanid is recommended in combating insect pests, attention is directed to the extremely poisonous nature of this substance. There are on record no fatalities due to the use of potassium cyanid as an insecticide against orchard pests, but this is because the danger from careless use was well known and simple precautions were observed. In weighing the doses it is recommended that the hands be protected by leather gloves, and after starting the generation of the gas the operator should avoid breathing until he is outside in the open air. A slight choking sensation experienced when standing close to the tents during the fumigation acts as a danger signal, and one should not persist in remaining where the gas is dense enough to produce this result. The acid should always be handled with great care. In addition to precautions necessary for the safety of the operators, care should be taken to avoid the scattering of small particles of the cyanid where fowls or other animals might become poisoned. As this substance is readily soluble in water and is deliquescent, or capable of liquefying through the absorption of moisture from the air, small particles accidentally dropped soon disappear.

Other precautions which it seems desirable to emphasize at this time concern the avoidance of damage to the tents and trees. Tents should never be dragged over the ground where the residue of the jars has been poured out on the surface or where the material has boiled over during the generation of the gas. The safest rule is to avoid entirely the dragging of tents across sections of the grove which have been recently fumigated. The residue or contents of the jars after fumigating is very destructive to citrus trees if emptied against the base of the trees. When emptied 3 feet or more from the base of the trees there seems to be no danger whatever unless roots are exposed, but to avoid all risk it is recommended that the practice be adopted of burying the residue halfway between the rows, as described under the subject of methods of procedure. Tents should not be left during the day covering trees which are to be fumigated at night, for the inside temperature is quite likely to be raised to a point where the gas will cause excessive shedding of the foliage.

EXPENSE OF FUMIGATION.

FOR EQUIPMENT.

The cost of the equipment, aside from the fumigating tents, is of little importance. In procuring a set of tents one may either purchase the material and arrange for the construction to be done by a tentmaker according to directions, or the maker may provide the material and furnish the tents according to specifications at regular prices. It will be found advantageous to obtain quotations from several tentmakers before placing an order. To give an idea of the usual cost of fumigating tents in California, the following schedule of prices recently quoted by a leading maker of fumigating tents in that State is given:

TABLE XII.—*Schedule of prices for sheet and bell fumigating tents.*

Sheet tents, 8-ounce duck.		Bell tents, 6½-ounce drill.	
Diameter.	Price.	Dimensions.	Price.
Feet.		*Feet.*	
17	$6.12	6 by 7	$2.66
24	12.24	8 by 9	4.55
30	18.90	6 by 12	5.72
36	27.00	9½ by 11	6.76
41	34.20	10½ by 14	9.10
43	41.40	12 by 15	13.00
45	43.74		
48	47.70		
52	59.40		
55	65.70		
64	86.40		

The cost of the sheet tents would be considerably reduced by the use of one or two widths of 6½-ounce drill, sewed around the margin as a skirt, as described under the subject of construction of fumigating tents. The difference between the cost of tent materials in California and in eastern citrus-growing States, owing to the greater distance of the former from the factories, should result in a reduction of from 2 to 5 per cent in the cost of an outfit at any point in the Gulf States. In Florida the season for fumigating against the white fly extends over from seven to ten weeks. During this time a fumigating tent, used between thirty-five and fifty days on an average of eight hours per day with forty-five minute exposures, would be used to cover between 280 and 400 trees. A tent large enough to cover the largest trees should ordinarily not cost over $110. It has been stated that the tents used in the author's experiments in January and February, 1907, have not deteriorated appreciably. With proper care tents should last several seasons, whether untreated or mildew-proofed. If such a tent as referred to above should be used for only three seasons, and be used to cover only between 280 and 400 trees each season, the cost of the wear and tear of the tent would amount to only from 9 to 12 cents per tree. Even taking into consideration interest on the money invested, the cost per tree would not exceed 15 cents. This is fully twice the cost of a tent large enough to cover trees of average size.

In many cases it would not be advisable for an orange grower to invest several hundred dollars in fumigating tents for his exclusive use, although many with extensive groves would doubtless prefer to do this. When possible individual ownership of an outfit is desirable. In some citrus fruit growing countries where fumigation is practiced against scale insects several growers form a club and share the cost of the fumigating outfit, which is left at the disposal of each of the members in turn. Such a plan might be followed in many cases in Florida. It is especially to be recommended where several groves constitute a naturally isolated group, and cooperation has all the advantages of individual ownership of a single isolated grove. A few citrus growers with a crop worth on an average $25,000 would not be put to unreasonable expense in the joint ownership of an outfit costing $1,200 or $1,500. The rapid growth of the idea of orange growers' associations in Florida during the past few months leads to the hope that a means is at hand for providing for systematic campaigns against citrus pests. In some cases associations for this purpose have already been organized. Fumigation by the contract system, as it is now done to a large extent in California, may also come into use in Florida. The plan which can be most strongly recommended is for the work to be done by the various counties. Each

county where the citrus-growing interests are of importance should maintain an outfit of tents large enough for the needs of the orange growers within its limits, and fumigation should be done at cost under the direction of the county horticultural commission.

FOR CHEMICALS.

The principal item of expense in connection with fumigation is the potassium cyanid. Fumigation was considered profitable in California when this was sold in quantities for 65 cents per pound. At present in lots of 100 pounds this can be procured for about 30 cents per pound, while in ton lots the cost is from 20 to 23 cents per pound in Florida. Sulphuric acid in iron drums containing about 1,500 pounds can be obtained for about 1¼ cents per pound. In carboys containing about 200 pounds the cost is about 2 cents per pound.

FOR LABOR.

In California, labor is usually paid for by the hour. The foreman in charge of the outfit is generally paid about 40 cents per hour and the remainder of the crew about 25 cents per hour. A crew of seven men, which might be used to advantage with the method of procedure herein recommended for use in fumigating for the white fly, would cost $15.20 for a night's work of eight hours if wages were paid at the above rates. These men could ordinarily handle from 10 to 15 tents of the largest sizes every forty-five minutes and fumigate 80 to 120 trees in eight or nine hours. If 80 trees were treated, the cost for labor would be about 19 cents per tree. If smaller tents were used and handled with changing poles, the same crew could treat 200 trees in eight hours at a cost for labor averaging about 7½ cents per tree. If six men proved sufficient to do this work, the cost for labor would be about 1 cent less per tree. In California contractors charge from 4 to 12 cents per tree for covering trees which can be covered without the use of the braced uprights or derricks. These prices include from the contractor's standpoint: First, cost of labor; second, cost of wear and tear on tents; third, a reasonable profit. Contractor's prices stated above are exclusive of about 3 or 3½ cents per pound usually allowed as payment for handling the cyanid, the chemicals being furnished by the owner of the grove.

In estimating the expense for labor in fumigating a grove there should be included, in addition to the labor in connection with covering the trees and generating the gas, an allowance for repairing tents, hauling chemicals and water, and miscellaneous work. This ordinarily ranges from 1 to 4 cents per tree, according to size.

ECONOMY OF TREATMENT BY FUMIGATION.

LOSSES PREVENTED.

Losses from the white fly.—When once the white fly (figs. 8, 9) is reduced to an inconsiderable quantity in a grove, much benefit will result from careful inspections and fumigations of single trees, or groups of trees, from time to time wherever the insects are found to be multiplying. This will greatly delay the time when the multiplication of the insects shall have made a general treatment again necessary. This practice is followed in California in the control of various scales. In well-cared-for groves, or where the county horticultural commissioners require it, scales are kept in complete subjection by fumigation and the appearance of only a few live scales on a tree is considered a reason for fumigating it and perhaps, also, surrounding trees as well, although these may appear entirely free from the pest. The best results from fumigation are obtained when once the various pests are brought under control by continuing the practice as a preventive rather than as a remedy. In other words, when conditions for successful fumigation for the white fly are favorable or after they have been made so,[a] fumigation can be practiced with such success that all damage from the white fly will be obviated. When once the practice has been adopted a grower should not wait until the foliage is blackened by the insects before fumigating the second time. It would be far more economical to fumigate regularly once in two years, and prevent all blackening of the foliage, than to fumigate once and wait until the fly

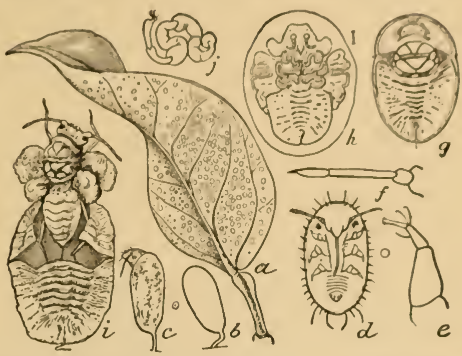


FIG. 8.—White fly (*Aleyrodes citri*): *a*, Orange leaf, showing infestation on under surface, natural size; *b*, egg; *c*, same, with young insect emerging; *d*, larval insect; *e*, foot of same; *f*, larval antenna; *g*, scale-like pupa; *h*, pupa about to disclose adult insect; *i*, insect escaping from pupal shell; *j*, leg of newly emerged insect, not yet straightened and hardened. All figures except *a* greatly enlarged (reengraved from Riley and Howard).

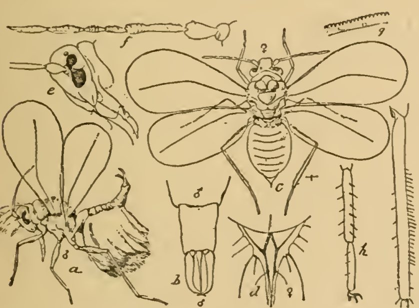


FIG. 9.—White fly (*Aleyrodes citri*): *a*, Winged male insect, with enlarged view of terminal segments at *b*; *c*, dorsal view of winged female, with enlargements of ovipositor, head, antenna, wing margin, and leg at *d*, *e*, *f*, *g*, *h*, *i*. (Reduced from Riley and Howard.)

[a] See discussion of this subject, pp. 9–14.

had increased sufficiently to cause blackening of the foliage and fruit before repeating the treatment.

The extent of the damage due to the white fly is difficult to estimate. After supplementing his personal observation with direct information and estimates on this point from more than 50 orange growers who have had experience with the pest, the author would consider 50 per cent a conservative estimate of the average annual loss in white-fly-infested groves.

The consensus of opinion of the orange growers referred to is to the effect that the reduction in the size of the crop alone amounts to 50 per cent or more, leaving out of consideration the loss through the checking of the growth of trees, the retardation of ripening, the expense of washing the fruit, and the impairment of its shipping quality and flavor. In many cases the damage from the fly renders citrus fruit growing unprofitable, although such losses are usually unnecessary if proper care be given to cultivation and fertilization. The beneficial effect of the fungous diseases of the white fly and the economy of fumigation where the diseases are prevalent will be discussed under another heading. The data at hand concerning the cost of fumigation indicate that in most cases the expense would be sustained by the increase in production if the losses of the white fly were only 10 per cent, instead of the 50 or more as generally estimated.

Losses from scale insects.—In calculating the benefits derived from fumigation, the effect of the treatment on other citrus pests is an important consideration. Fortunately the high average of humidity in the citrus-growing sections of the Gulf States results in the partial control of scale-insect pests which would otherwise make direct remedial measures necessary for profitable crops. The thoroughness of this natural control varies greatly in different groves according to local conditions. Fruit infested with the purple or the long scale is far less valuable, as a rule, than is clean fruit. If such fruit is cleaned before packing, the cost is usually from 10 to 15 cents per box. In the markets scaly fruit in rare instances brings as much as fruit free from scale, but ordinarily it brings from 25 to 75 cents less per box, even after being cleaned by hand. If not cleaned it may fail to find a market at any price. When handled by orange buyers and sold upon the tree, even a small percentage of scaly fruit frequently results in a considerable loss in selling value of the entire crop.

Direct information has been obtained from many orange growers and shippers concerning the effect of scales upon the value of fruit. The damage reported ranges from none at all to 26 per cent of the total value of the crop. Ordinarily from 5 to 15 per cent of the crops of oranges and grapefruit are sold as of an inferior grade owing to infestation by the long and purple scales. One grower in Lee County reported that last season (fruit shipped in December, 1906) he suffered a loss of $1,500 on a crop of 1,000 boxes of oranges and 2,000 boxes of

grapefruit. All of the grapefruit and 300 boxes of the oranges were scraped by hand to remove the scale. This operation cost between $275 and $300. The loss to the selling value of the oranges was about $225 and of the grapefruit about $1,000. Many instances have come to the writer's attention of losses from scale amounting to 5 per cent of the total value of the crop. In addition to direct losses of the kind noted above, frequently more serious losses are suffered as a result of the complete destruction of branches and weakening of the vitality of the trees by the heavy incrustations of the scales upon the main branches or trunks. The total damage from scales in Florida is usually too small to make direct remedial measures profitable, but when this damage can be to a large extent obviated at the same time with that of the white fly, the matter demands careful consideration. It is the writer's conviction that in the cases of the majority of groves the destruction of the purple, long, Florida red, and other scale insects would represent an increase in profit which would by itself offset the cost of fumigation, leaving as clear gain the benefits derived from reducing the numbers of the white fly to a negligible quantity.

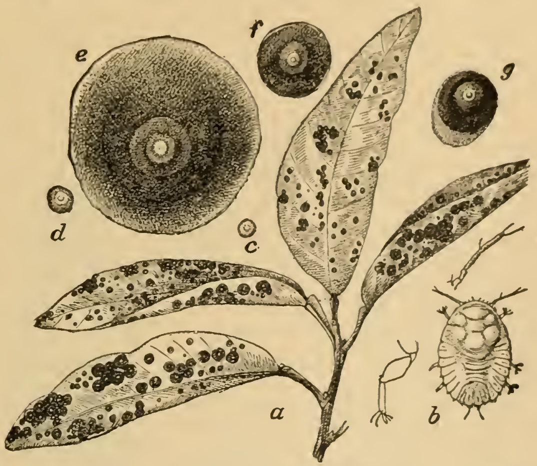


FIG. 10.—Florida red scale (*Chrysomphalus ficus*): *a*, Leaves covered with the male and female scales, natural size; *b*, newly hatched insect with enlargements of antenna and leg; *c, d, e, f*, different stages in the development of the female insect, drawn to the same scale; *g*, adult male scale, similarly enlarged. (After Marlatt.)

The Florida red scale (*Chrysomphalus ficus* Ashm.) (fig. 10) is destroyed with a thoroughness near to absolute extermination by the same dosage which is required for the white fly. This has been conclusively proved by the experimental work conducted by the writer and Mr. W. W. Yothers in January of the present year. Not infrequently in Florida the scale insect referred to causes sufficient injury to make fumigation a very profitable procedure against this insect alone, leaving out of consideration the effect upon the other pests present.

The purple scale (*Lepidosaphes beckii* Newm.) (fig. 11) sometimes called the "brown," "oyster-shell," or "hard" scale, is of greater economic importance than the Florida red scale on account of its more wide-spread distribution. The results in controlling this pest accomplished incidentally to work against the white fly are most encouraging. In the same grove where the effect of fumigation on the Florida red scale was observed, the purple scale has been so abundant for years

that the owners' fruit-shipping records show annual losses from this source amounting to between 15 and 20 cents per tree. Live scales in all stages, particularly the egg and adult, were very abundant before fumigating, but up to the 1st of June careful examinations of thousands of leaves, twigs, and green fruits by Mr. Yothers and the writer have not led to the finding of a single living specimen of this species in the section of the grove which was the most heavily infested. At this season of the year there is usually no difficulty in finding more or less abundant specimens of the spring brood of this insect even where it was so scarce the previous season as to occasion no appreciable damage to the crop.

COST OF FUMIGATION COMPARED WITH SPRAYING.

In Florida the average cost of spraying is between $2\frac{1}{2}$ and 3 cents per gallon of spray applied. When spraying is done with such effi-

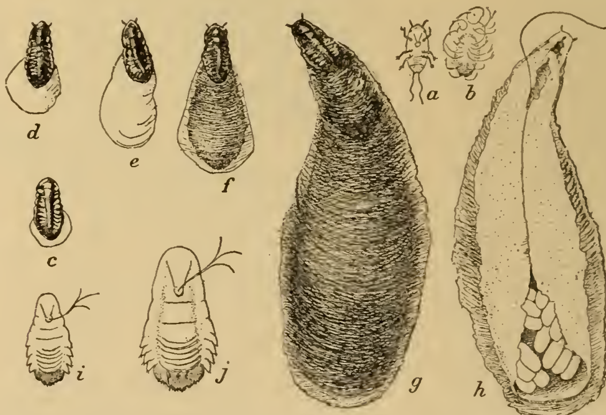


FIG. 11.—Purple scale (*Lepidosaphes beckii*), showing different stages of female: *a*, Newly hatched larva; *b*, same with first waxy secretion; *c* to *f*, different stages of growth; *g*, mature scale; *h*, same inverted, showing eggs; *i* and *j*, half-grown and full-grown female insects removed from scale. All much enlarged (after Marlatt).

ciency that blackening of the foliage and fruit by the sooty mold is prevented, at least three applications per year, and usually four or more, are necessary. The mechanical difficulties of spraying with as much effectiveness as this are so great as to make the results with ordinary practices far inferior to those from fumigating. In fact the results with sprays have with few exceptions been unsatisfactory in controlling the white fly or preventing the blackening of the fruit and foliage. In many cases this is largely a result of the character of the labor which it is necessary to employ for such work. For the purposes of comparing spraying with fumigating in regard to cost, it may be considered that three applications of sprays per year will control the white fly in a satisfactory manner, although in actual practice this is rarely accomplished unless drought or fungous diseases offer material aid

The tented tree shown in Plate VI, figure 2, measured 42 feet over the top from ground to ground and 59 feet in circumference. According to the table given in the appendix a tree of this size should be given 26 ounces of potassium cyanid. In covering a tree of this size ordinary changing poles could be used instead of the upright shown in the illustration. The entire cost of fumigating the tree for the white fly is estimated at 50 cents. This includes 36 cents cost of potassium cyanid, 3 cents cost of acid, 6 cents cost of labor, and 5 cents cost of wear and tear on the tent. The tree shown at the left of the tent in Plate VI, figure 2, measured 44 feet over the top and 53 feet in circumference. According to the tables the tree requires 25½ ounces of potassium cyanid, the cost of fumigating therefore being practically the same as for the first tree mentioned. Each of these trees if sprayed would require six or seven gallons of liquid at each application. Three applications in a year at the usual cost would be from 45 to 63 cents as compared with 50 cents for fumigating. The tree shown in Plate I measured, when tented, 33 feet over the top and 38 feet in circumference. A tree of this size requires 12 ounces of potassium cyanid for effective fumigation. The total cost of one fumigation would be about 27 cents, including 16 cents as cost of potassium cyanid, 6 cents as cost for labor, 1 cent as cost for acid, and 4 cents for wear and tear on the fumigating tent. A tree of this size would require at least 3 gallons of spray at each application, and during the year the cost for three applications would be from 22 to 27 cents.

These data on the comparative cost of the two methods of control show that the advantage of fumigation over spraying for the first year is a matter of greater efficiency, except when more than three applications of spray are made, when fumigation is also less expensive. Fumigation, however, in an isolated grove or under favorable conditions as to location, when properly conducted would not require repetition for two or more years. The best of spraying could not, unless aided by abnormal climatic conditions, so reduce the white fly that the number of applications could be lessened the second year without interfering with the degree of success attainable by the practice. In two years the cost of spraying the trees above referred to would double the cost of one fumigation. In a series of five or more years spraying would doubtless cost fully three times as much as would control by fumigation, the labor involved would be far greater, and the results far less satisfactory.

FUMIGATION VERSUS NATURAL CONTROL.

The present investigation of the white fly by the writer and his associates covers all phases of the subject. Due consideration is given to all possible sources which give basis for the hope of effecting economical control. The exposed condition of the pest under consideration, its vulnerability to attack by natural enemies, the high degree of humidity in the citrus-growing regions of the Gulf States which

favors the effectiveness of fungous and bacterial diseases, all give basis for the hope that complete control by natural enemies will be the eventual conclusion of the white-fly problem. A thoroughly scientific and practical investigation, however, can not lead to lasting benefits if the conclusions represent merely desired results and are unsupported by sufficient evidence and experience. While a great deal has been learned concerning the fungous diseases of the white fly, the present investigations of this Bureau have not thus far shown that any method can be relied upon to materially assist nature in controlling the pest to the point of preventing all or nearly all of its injury. The dissemination of these diseases is readily accomplished under certain favorable conditions, but how far artificial dissemination, at its best, with our present methods goes toward the successful control of the white fly is still problematical.

Manatee County is the only large orange-growing district where the fungous diseases have proved of much assistance. Data obtained from many orange growers and personal observation by the writer and other entomologists connected with the Bureau of Entomology indicate that the fungi, without artifical aid, reduce the injury from the white fly about one-third. Undoubtedly without the aid of these fungous friends the damage in Manatee County would average more than 50 per cent. With this as a minimum estimate, the average damage in Manatee County, allowing a benefit of one-third from the fungi, amounts to 34 per cent. One year in three, it is the experience of the growers in this county, the fungi have so thoroughly cleaned up the pest that the fruit is clean and requires no washing. The following year the insects are in the ascendency and the fruit and foliage become blackened with sooty mold to as great an extent as can be observed anywhere in the State. This is due to the fact that the fungi have diminished the white flies the previous year to a point where they cease to flourish. Late in the second year, however, with the fly abundant, the fungous enemies develop rapidly. The third year the effect of the blackening of the foliage is apparent in a greatly reduced crop, while during this year the fly is again reduced to a negligible quantity, permitting a good crop of fruit to set and remain clean from sooty mold during the following season. The above is the usual course followed in individual groves. Considering the county as a whole in 1906, fully three-fourths of the groves were so free from sooty mold as to require no washing of the fruit. It was generally considered that this condition had never before been equaled since the white fly first obtained a foothold in this county. In one case, however, it was claimed by one of the leading orange growers that an isolated grove had become practically clean through some unknown agency, the prevailing fungous diseases not being present in sufficient abundance to accomplish any noticeable result. Nevertheless, the fungous enemies referred to were undoubtedly of prime importance

in producing the high degree of freedom from white-fly damage attained in 1906. Other conditions may have had minor influence. As a natural consequence of the lack of abundant food for the fungous parasites in 1906, the situation in 1907 showed a complete reversal, with more than three-fourths of the groves thoroughly blackened by sooty mold. It is not uncommon to find that individual groves vary considerably from the average condition of the groves in the county as a whole.

In the close vicinity of Fort Myers, in Lee County, the fungi have reduced the numbers of the white fly to a greater extent than observed at any other place. The result of this is to cause a considerable variation from the usual succession of predominance of host and parasite, but in the course of a ten-year period the benefits from the fungous diseases under natural conditions will evidently be little if any greater than in Manatee County. In the town of Fort Myers the conditions are not comparable with those in large commercial groves. In one such grove, however, located on the south side of the Caloosahatchie River, nearly opposite Fort Myers, the fungous diseases have proved more than ordinarily beneficial during the past two years. There is strong evidence even here that the white fly will regain its usual abundance in the course of the present season unless artificial methods of control are resorted to or experiments result in the discovery of a more satisfactory method than is now known of artificially encouraging the growth and spread of the fungous enemies.

The writer's observations lead to the conclusion that in 99 per cent of the groves in those localities where the fungous diseases are most effective, for every dollar expended for well-conducted fumigation the profits from the groves will be increased not less than $4, or at the rate of 250 per cent on the investment. If the expense of fumigation were doubled the adoption of this practice would still be profitable, at least until such time as the natural enemies at hand can be made more successful or new ones discovered to accomplish effective control.

The spores and mycelium of the fungi are not affected by fumigation, as far as has been determined thus far. In experiments in the artificial dissemination of the brown and red fungous parasites the results obtained were as satisfactory when the material was collected from fumigated trees as when collected from those not fumigated. Ordinarily this point is of little importance, since successful fumigation would always result in practically absolutely checking the further multiplication of the parasites through the destruction of the host insects. The further multiplication of the fungous parasites following fumigation is therefore an indication of ineffectiveness of the treatment or of the increase in the numbers of the pest through migration from untreated groves.

APPENDIX.

TABLE OF DOSAGE FOR THE CITRUS WHITE FLY.

The table of dosage herein given is based upon the author's experiments conducted in January and February, 1907. The mathematical calculations are tabulated and explained in the body of this bulletin. The most important object of fumigation experiments against the white fly has been the development of methods for the practical utilization of the fumigation process in Florida and the gaining of a knowledge concerning the dosage requirements. The former subject has already been disposed of through the methods herein described. The investigations concerning the latter subject have resulted in placing fumigation for the white fly on a basis whereby the process may be used against this insect with greater economy, thoroughness, and certainty of results than at present it can be used against any other species. Incidentally it should be remarked that the dosage requirements for the white fly are greater than for the Florida red scale and perhaps greater also than for the purple scale. It is beyond the scope of these investigations to determine the possibility of reducing the dosage below the white fly standard without interfering with its efficiency against these other pests. It is sufficient to know in most cases that the white fly dosage is equal to the actual requirements for the pests of secondary importance. The dosage table here presented does not necessarily represent the exact amounts for greatest utility in the case of the different sizes of trees. The extensive tests of the dosage table during the past winter, when, as has been stated, nearly 4,000 trees were fumigated under the direction of the agents of the Bureau of Entomology, show the doses recommended to be very close to the necessary amounts with tents of equal tightness with those used in the original experiments. The dosage should never be decreased when effective work against the white fly is desired, but under certain conditions it may be increased from 10 to 25 per cent with advantage.

If there is a slight breeze of sufficient strength to make the advisability of fumigating questionable, an increase in dosage of 10 per cent or more may allow the work to proceed without interfering with the efficiency; but with ordinary tents of 8-ounce duck such increases do not offset the effects of strong or gusty breezes, which sway the

sides of the tent. If the only available tents are of inferior quality and fall short of being as nearly gas-tight as the best of material, increases in dosage may be advisable. When it is desired to fumigate with a thoroughness approaching extermination, an increase may be made of from 10 to 25 per cent. Such a course is frequently advisable to check the further spread of the fly in newly infested localities or in newly infested groves. In the fumigation of very small trees, 20 feet over or less, there seem to be certain factors sometimes interfering with efficiency which have not so far been thoroughly investigated. It is possible that in the using of crocks of 2 or 3 gallons capacity for doses less than 5 ounces the mixture of acid and water fails to generate sufficient heat to cause quick chemical action, the heat absorbed by the jar being the disturbing factor. This may be partly obviated by using powder or very small lumps of potassium cyanid when the dose is 5 ounces or less, but it seems advisable also to increase the amount by one-half or three-fourths above the recommended dose. If the size of the crock and consequent undue loss of heat is the principal disturbing factor, future experience may show that it is desirable to have on hand for use in fumigating very small trees a supply of half-gallon crocks or 1-quart stone chinaware pitchers.

In the table the amount in each case represents the next half ounce above the dosage which the detailed estimate calls for, whenever this dosage was more than one-tenth ounce above the even ounce or half ounce. For example, when the detailed calculation calls for 19.2 ounces the number in the working table is 19½ ounces, and when for 19.7 ounces the number is 20 ounces. In using the table in the field, when the reading on the graduated tent shows the approximate distance over the top to be an odd number of feet, the next even number above should be selected. In the same way, when the exact circumference is not shown at the top of the table, the next highest number should be selected.

To illustrate the method of using the table of dosage, the following examples show the measurements and dosage called for in the case of five trees of various sizes:

Measurements of, and dosage for each of five trees of various sizes.

Distance over tented tree.	Circumference of tented tree.	Amount of potassium cyanid called for.
Feet.	*Feet.*	*Ounces.*
28	45	10
48	60	34
54	68	47
60	74	61
72	80	89

At all times it should be borne in mind that it is advisable to use one-half or even 1 ounce more than called for by the table rather than the smaller amount.

Proper dosage (quantity, in ounces, of potassium cyanid) for fumigating, based upon the distance over and the circumference, in feet, of the tented tree.

Distance over.		Circumference.																								
		10	15	20	25	30	35	40	45	50	52½	55	57½	60	62½	65	67½	70	72½	75	77½	80	82½	85	87½	90
	10	1	1	1																						
	12	2	2	2																						
1	14	2½	2½	2½	2½																					
	16	3	3	3	3	3																				
	18		4	4	4	4	4																			
	20		4½	4½	4½	4½	4½																			
	22			4½	5	5½	5½	6																		
2	24			5½	6	6	6½	7	7½																	
	26				7	7	7½	8	8½																	
	28				8	8½	8½	9	10	10½																
	30					9½	10	10½	11	11½																
	32					10½	11	11½	12½	14	15															
3	34					12	12	13	14	15½	16½	18														
	36						13½	14½	15½	17	17½	18½	19½													
	38						15	16	17	19	19½	20½	21½	22½												
	40							17½	18½	20½	21½	22½	23½	24½	25½											
	42							18½	20½	22½	23½	24½	25½	26½	27½	28½										
4	44								22	24	25	26½	27½	28½	29½	31	32	33½								
	46									26	27	28½	29½	31	32	33½	34½	36	37½	39						
	48									27½	29	30½	31	33½	34½	36	37½	38½	40	41	42½					
	50										31	32½	34	35½	37½	39	40½	42	43½	45	46½	48				
	52											34½	36	38	40	41½	43	44½	46½	48	50	51½	53½			
5	54											37	38½	40½	42	44	46	48	50	51½	53	54½	56	57½		
	56												41	43	45	46½	49	51	53	54½	57	59	61	63	65	
	58												43	45	47	49	51½	54	56	58	60½	62½	65	67½	70	
	60													48	50	52	54½	56½	59	61	63½	65½	68	70	72½	75
	62													50	52½	55	57½	60	62	64½	67	69½	72	74½	77½	
6	64													53½	55½	58	60½	63	65½	68	70½	73½	76½	79½	82½	85
	66													55½	58	61	64	67	69	71	74½	78	80½	83	85½	88
	68													58½	61	64	66½	69½	72	75	78	81½	84½	87½	90½	93½
	70													61½	64	66½	69½	72½	75½	78½	82	85	88	91	94	97
7	72													64	66½	69	72	75½	79	82½	86	89	92	95	98	101½
	74													67½	70	71½	75	78½	82	86	89½	93	96	99½	103	106
	76													70	73	75½	79	82	86	89½	94	97	100	103½	108	111½

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